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A battery of four psychomotor tests was developed and evaluated as a measure of the potential of mental patients of varying diagnoses for rehabilitation training. The tests were to be suitable for administration and interpretation by non-professional level technicians. The relationship between performance on the 5 days of tests and patient outcome 1 year later was studied in 996 patients of varied diagnoses. Results indicated that the major share of significant differences on psychomotor performance occurred between two clusters of diagnoses: schizophrenic, manic depressive, and personality disorder on one hand; and chronic brain syndrome plus mentally deficient on the other. Through multiple correlation and regression analyses, accuracy of test prediction was found to be 70 to 78% correct. However, variations in discharge rate and level of performance among diagnostic groups limited the use of a cut-off score suitable for all diagnoses, and the small number of cases per diagnosis prevented development of separate norms. It was concluded that an inverse relationship exists between quality of psychomotor performance and severity of mental disease (coefficient of multiple correlation = .50 to .65). The method developed has applications in the selection of patients for training. An 86-item bibliography, 46 tables, and 17 figures are provided. (Author/JD)

Duplicate

Psychomotor Performance, Mental Disability and Rehabilitation

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Final Report, VRA Grant RD 1291

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PSYCHOMOTOR PERFORMANCE, MENTAL DISABILITY AND REHABILITATION

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INTRODUCTION

One of the most difficult problems in the administration of a rehabilitation program for mental patients centers around the proper selection of patients for training. Usually there are many more patients than spaces available and the problem is to avoid slowing the rate of turnover by selecting patients who can be expected to 'graduate' more rapidly. The converse of this problem is the tendency of staff to overlook the quiet, unobtrusive patient who does little to attract attention.

What is needed is a simple way to organize or order a group of patients in terms of their probable success in rehabilitation training. Preferably this method should make minimal demands on professional staff time, require only simple equipment, and be administered and scored by aides with a minimum of additional training.

We believe that the system to be described in this report will fulfill most of these requirements, provided that it is used with care and interpreted with due regard to its stated limitations. The method is clearly an adjunct to and not a substitute for clinical judgment. For example, the tests can indicate that a paranoid patient is capable of psychomotor function which would enable him to hold employment outside the hospital, but it will not reflect the fact that his delusional system may make his release inadvisable and employment impossible. Such evaluation is currently, and may well remain, in the province of clinical judgment.

This report will be concerned with the use of the battery of psychomotor tests in selecting for rehabilitation training mental patients of varying diagnoses from the population of a state mental hospital.

The use of psychomotor performance measures on mental patients is not new. There has been a persistent effort over nearly the last one hundred years to apply these instruments to varying population of mental patients. Most efforts were made either in the hope of developing a differentially diagnostic tool or in distinguishing the ways in which the mental patient differed from the normal.

The first aim appears to have been completely frustrated. To our knowledge, there have been no successful attempts to categorize mental patients into diagnostic groups on the basis of test performance. Considering the imprecision of diagnostic criteria, the failure may not be ascribed entirely to the psychomotor measures.

Attempts to differentiate the normal from the mentally ill have likewise been unsuccessful so long as the individual rather than the actuarial approach has been used. It has been an almost universal finding that the mentally ill perform more poorly than do normals and that the degree of impairment is correlated with the severity of the mental illness. However, there is sufficient overlap in the performance ranges for the two groups to make the assignment of a given individual to the normal or mentally ill group so imprecise as to be clinically useless.

This report will not be concerned with an elaborate review of the literature concerning psychomotor tests and mental patients. The interested reader is referred to the list of references for a selection of titles which will indicate the diversity to be found in the area. An excellent review of the literature is to be found in King (1954). An exhaustive bibliography of titles dealing with psychomotor performance, not limited to mental patients, has been published by Ammons and Ammons (1964). In recent years there has been an increased use of psychomotor test performance in the analysis of drug effects. (Benjamin et al 1957, Lehman and Csank 1957, Karnetsky and Humphries 1958, DiMascio and Renkel 1960, Peshkin 1962, Klugman 1962, Pearl 1962)

Broadly summarized, their findings might be said to indicate that tranquilizing medication tends to adversely affect normal subject performance and to improve that of mental patients, a finding in harmony with the numerous reports of impaired performance in mental patients.

The work done in our laboratory on psychomotor testing of mental patients has taken several directions. Initially we partially confirmed the findings of King (1954) with respect to the differentiation of degree of mental illness in terms of psychomotor test performance (Weaver 1961). The effects of drug-induced Parkinsonism on psychomotor performance of schizophrenic patients was investigated (Weaver and Brooks 1961) with the finding that the psychomotor test battery was differentially sensitive to Parkinsonism. Fine coordinated movements were affected first and to the greatest degree.

A study of the relationships between psychiatric status and psychomotor performance (Brooks and Weaver 1961) indicated clearly that psychomotor test performance detected the exacerbation of psychotic symptoms under placebo medication before this became clinically apparent and also showed evidence of recovery under tranquilizing medications before the clinical manifestations of psychosis were reduced.

These findings led to a study of the use of psychomotor test performance as a means of predicting rehabilitation readiness or potential of schizophrenic patients (Weaver and Brooks 1963). This study indicated that the psychomotor test battery could select, at a statistically significant level, those patients who would eventually leave the hospital. Cutting points could be selected which would maximize the selection of successful patients or minimize the selection of unsuccessful patients, according to the purposes for which the test was being given. It should be emphasized that this was a concurrent study of a rehabilitation process already in operation. The tests were not used to evaluate patients for rehabilitation training or release, thus maintaining the necessary independence between criterion and test measures. The approach assumes that substantially all the patients ready for discharge will be detected and released, an assumption made reasonably tenable by the very active rehabilitation program at the research hospital.

The success of this technique applied to schizophrenic patients raised the question of application to the general population of a state mental hospital. The remainder of this report will be devoted to this topic.

For the benefit of readers interested in the research milieu, a brief description of the research hospital follows. The Vermont State Hospital, the only public mental institution in the state, is a medium-sized hospital with an average patient population of 1220 patients. There are about 700 admissions or readmissions and 575 discharges per year. There has been a slight reduction in the average daily population in the last ten years but a marked increase in the number of admissions. The hospital admits all types of severe mental disorders, except for the mentally retarded, from the entire state of Vermont. The hospital currently employs 11 physicians, 20 nurses, 4 social workers, 3 clinical psychologists, 2 teachers, a recreational therapist, an industrial therapist, and 275 psychiatric aides. It has an active research department, operated in conjunction with the University of Vermont, which employs a full-time sociologist, an experimental psychologist, 3 research assistants, 4 secretaries, an electronics technician, and 4 vocational instructors.

At Vermont State Hospital there is a strong rehabilitation program. One aspect of this is to provide basic vocational training for small groups of chronic patients geared to agricultural, industrial, domestic, nursing, maintenance, and commercial skills. The aim of the in-hospital vocational training program is to prepare patients to leave the hospital via the use of a rehabilitation house.

It is tied to the rehabilitation house program which is sponsored by the Vermont Department of Vocational Rehabilitation. The principle of the 'half-way houses' is to offer residence for a period of months. During this time, through the assistance of a vocational counselor, the residents work in the community and become accustomed to community life on a graduated basis with the result being a full return to community living.

Chapter 2

METHODOLOGY

The basic design of this study is the classic industrial psychology approach to test validation. In this design the instrument under study is administered to a selected sample of the population. The results are not allowed to influence the fate of the sample members. When a sufficient time has elapsed to make possible a reasonably stable estimate of the success or failure of the subjects, the test results are compared with the outcome data to determine whether the test results could be used to select individuals more efficiently than the method currently in use.

The method has several limitations which must be considered in connection with the present study. Primarily, it assumes complete independence of the test and criterion measures in the sense that test performance is not allowed to affect either the subsequent actions of the subject nor evaluation of subject performance made by a third party. Failure to control this aspect results in a form of circular validity.

The second limitation is that the method assumes a virtually unrestricted sample of the population to which it is to be applied. This is necessary to prevent discard of sample members who are eliminated for other reasons. This limitation does not operate to affect the definition of the population to which it is to be applied but does require unrestricted sampling of the defined population.

A third limitation is that a sufficient amount of time must be allowed for post-test criterion performance. Lack of sufficient time tends to decrease the sensitivity of the criterion measure and obviously, the validity of a test is limited by the criterion measures.

Turning now to the design of the current study, the research question concerned the ability of the psychomotor test battery to determine which patients from the general hospital population would be released. The general hospital population is defined as all patients with certain exclusions made for largely pragmatic reasons. The first excluded category is patients confined through legal rather than medical process, an exclusion justified by the fact that the criterion measure (leaving the hospital during the post-test observation period) is influenced by the legal aspects and differs markedly from the criteria applied to the ordinary patient.

The second exclusion is based on chronological age. As the only state mental institution, a large proportion of the resident population consists of elderly patients who are management problems for their families. There is little point in including these essentially terminal patients in a population of potential rehabilitation candidates since many would be unemployable at best. Hence a cut-off age of 60 years was used; a figure also used by the hospital in determining eligibility for rehabilitation training. In practice, a cut-off date of age 58 at date of testing was employed in order to assure compliance with the criterion used by the hospital. In view of the limited facilities for rehabilitation training available in most mental hospitals, the age limit is probably over-inclusive at the upper end.

At the lower end of the age scale, we have excluded only children not yet in the teens. The reason is simply that it is the lower adult age brackets which are most likely to receive rehabilitation training and hence the group for which a predictive device would be most useful.

The third limitation mentioned -- a sufficient length of post-test experience -- was likewise a matter of pragmatic balancing-off of various factors. Experience tables at the research hospital indicates the median length of stay at discharge for all patients is 2.2 months and about 3.2 months for psychotics. The mean length of stay for all patients was 6.7 months and about 10.8 months for psychotics. When consideration is given to the fact that the mean can be unduly influenced by the addition of a few long-stay cases, it seems clear that a post-test observation period of one year would include most of the cases who could be considered currently to possess much potential for rehabilitation. The purpose of the test battery was to select those patients who would profit most from rehabilitation training in terms of being ready to benefit from it. We felt that hospitalization for one year would indicate that the patient was, at the time of testing, less ready to benefit from training than the patient who was discharged within the year.

We are aware of the limitations and assumptions involved in this system, most of which are inherent and common to any research involving the use of human subjects in a therapeutic situation. The crucial assumption is that all patients who should be released in fact are released. This assumption is partially justified on the grounds that the hospital has a strong tradition of non-custodial treatment as well as an active rehabilitation effort. Evaluative procedures designed to prevent overlooking of recovered cases are systematically carried out. While the system is far from perfect in view of the small staff-patient ratio, it does seem to minimize a potentially serious source of error.

Subjects

The population for this study was defined as all patients in the Vermont State Hospital who were residents or who were admitted during the course of the study. As shown in Table 2.1, a total of 2175 cases were available. A total of 1203 useable records were obtained from this population. The majority of the losses were incurred in the 'over-age' and

Table 2.1

The distribution of the available population by diagnosis and disposition.

		Diagnosis						
	N	Schizo-phrenic	Manic De-pressive	Chronic Brain Syndrome	Person-ality Disorder	Mentally Deficient	Psycho-neurotic Reaction	Alcoholic
Tested	1203	645	87	107	92	88	82	102
Over-age	646	189	119	250	9	51	16	12
Expired	153	24	8	112	0	9	0	0
Untestable	112	31	3	38	1	38	0	1
Discharged before testing	61	13	7	1	11	0	21	8
Totals	2175	902	224	508	113	186	119	123
Per cent of total group in each diagnosis		41.5	10.3	23.4	5.2	8.6	5.5	5.7
Per cent of tested group in each diagnosis		53.6	7.2	8.9	7.6	7.3	6.8	8.5

'expired' categories. The over-age group included all patients aged 59 years or older at the time of testing. Hospital policy was not to select for rehabilitation training any person over 60 years of age. Since this could affect the discharge rate independently of the factors under study, the older group was not tested. Inspection of Table 2.1 shows a disproportionately heavy concentration of chronic brain syndrome patients in this group, probably indicating a large number of senile arteriosclerotics. Hence the exclusion seemed warranted.

A rather striking fact was that the incidence of untestable patients remained fairly low. Only 112 of 1376 patients (8%) could not be induced to cooperate. The fact that the tests could be applied to 90% of a mental hospital population selected only on the basis of chronological age may be accepted as evidence of the wide applicability of the technique.

A basic question is to what extent our group is truly representative of the population from which it was drawn. Obviously, there were non-random factors (age and testability) at work in the selection process.

At the bottom of Table 2.1 is presented the per cent of the total group falling in each diagnostic category. As might be expected, the majority of the cases fall in the schizophrenic and chronic brain syndrome categories. For ease in comparison, the same analysis is presented on the next line for the tested group. Only two major discrepancies were observed; an increase in the schizophrenic and a decrease in the chronic brain syndrome categories. The reason for these changes lies in the uneven distribution of the over-age group. Only 21% of the schizophrenic group was over-age while 49% of the chronic brain syndrome group fell in that class. The incidence of untestable was similar in both groups.

It was concluded that, for the purposes of this paper, the sample of 1203 cases does not differ significantly from the patient population.

One further correction was applied to the sample which reduced the size even more. While no control was attempted over such factors as number or length of previous hospitalization, it was deemed necessary to establish a minimum period of observation following testing. A common criterion has been outcome at one year following admissions. In this case we adopted as the criterion "status at the end of one year following testing" with certain modifications. Patients discharged during the year were classified as 'out'. Patients expiring with less than one year experience were dropped. Table 2.2 gives the changes in the group occasioned by the application of the one-year criterion.

It is obvious that the reduction did not materially alter the inter-group distribution. Considered in terms of per cent of the total, no diagnostic group changed more than one per cent. This group, as constituted, will be used in the investigation of the question of whether the different diagnostic groups perform differently on the psychomotor tests.

The factor of age is not particularly germane to the purpose of this study except that cognizance must be taken of the possible introduction of bias if the diagnostic groups should vary widely in age. The distribution of the 1184 patients by age and diagnosis is presented in Table 2.3 in terms of number of cases and in per cent of each diagnostic group.

Test Battery

The apparatus used in this study was developed in our laboratory during the first part of our research program. It has been reported elsewhere (Weaver and Brooks 1961). For this study, the test battery consisted of five tests.

Reaction time. In this test the subject (S) was seated in a chair facing the apparatus, with the right forefinger resting on a telegraph key. At the warning from the

Table 2.2

The distribution of cases in each diagnostic category for the tested and one-year post-test groups.

		Diagnosis						
	N	Schizophrenic	Manic Depressive	Chronic Brain Syndrome	Personality Disorder	Mentally Deficient	Psychoneurotic Reaction	Alcoholic
Tested	1203	645	87	107	92	88	82	102
Post-test	1184	636	84	102	91	83	86	102

Table 2.3

The distribution of the patient group by age, sex and diagnosis.
Cell entries are number of cases and per cent of
diagnostic group for each age level.

Age	Schizophrenic			Manic Depressive			Chronic Brain Syndrome			Personality Disorder			Mentally Deficient			Psychoneurotic Reaction			Alcoholic			Total Group			
	M	F	%	M	F	%	M	F	%	M	F	%	M	F	%	M	F	%	M	F	%	M	F	MF	%
20	27	15	7	1	1	2	10	2	12	19	20	43	5	2	8	4	7	13	2	0	2	68	47	115	10
21-25	32	27	9	2	4	7	6	2	8	5	3	9	2	3	6	4	6	12	8	2	10	59	47	106	9
26-30	32	32	10	4	2	7	9	2	11	5	4	10	6	3	11	2	10	14	9	2	11	67	55	122	10
31-35	37	44	13	0	5	6	1	5	6	8	4	13	6	2	10	2	8	12	8	3	11	62	71	133	11
36-40	38	52	14	3	10	15	8	3	11	4	5	10	4	3	8	1	8	10	11	1	12	69	82	151	13
41-45	38	59	15	2	8	12	8	7	15	3	2	5	8	4	14	4	9	15	11	4	15	74	93	167	14
46-50	39	43	13	6	10	19	10	3	13	2	2	4	5	4	11	2	7	10	16	1	17	80	70	150	13
51-55	30	42	11	4	7	13	11	10	21	2	1	3	11	10	25	2	6	9	16	1	17	76	77	153	13
56-60	19	30	8	6	9	18	3	2	5	1	1	2	2	3	6	0	4	5	7	0	7	38	49	87	7
Totals	292	344		28	56		66	36		49	42		49	34		21	65		88	14		593	591	1184	

experimenter (E), S depressed the key and attended to the stimulus lamp. At the stimulus onset, the light plus a tone of medium intensity, S lifted his forefinger from the depressed key. The elapsed time was measured by a .01 second electric timer.

Rate of Tapping. This test was designed to measure the ability of the patient to perform a rapid repetitive movement. S was seated in a chair facing the telegraph key. Following instructions to tap as rapidly as possible, S was given the verbal signal to begin. When S had begun to tap, E turned on the recording counter for five seconds. This method gave a sample of an on-going response unaffected by response time.

Transport-Assembly Test. This test is basically a modification of the Purdue Grooved Pegboard as described originally by Tiffin (1952). The test consisted of the pegboard, a magazine for the pegs, and the necessary circuitry for a capacitance-operated relay system.

The pegboard was about eight inches square and was drilled with a symmetrical pattern of 25 holes. Over this was a cover with a matching pattern of holes. Each hole in the cover has a slot or keyway extending radially from the edge of the hole. Each peg had a short stud projecting radially from its middle. The task of the subject was to procure a peg from the magazine, transport it to the board, insert it into a hole while aligning the stud with the slot, depress it against light spring pressure, and rotate the stud underneath the cover to retain the peg in place.

The task can be conveniently divided into two elements; transport of the hand to and from the magazine, and manipulation which consists of grasping the peg at the magazine and later inserting and twisting it in the hole. The times for these elements were cumulated separately and were recorded as 'Transport' and 'Assembly' scores respectively. Each were considered as a separate test in the analysis of the data.

Serial Reaction Time. This test consisted of five brass target plates, 1 1/2 inches in diameter, linerally arrayed on a horizontal surface 8 inches by 24 inches. The plates were spaced with 2 1/2 inches between adjacent edges. Each target had an associated red stimulus light. The task of the standing S was to touch with a wand the plate whose stimulus light was currently glowing. This response extinguished that lamp and turned on the next in the series. Twenty such responses constituted one trial. The order in which the lamps came on could be varied among five patterns. The patterns were so arranged that no stimulus light succeeded itself. The score consisted of the time necessary to complete the twenty responses. Five trials, one on each pattern, were given at each session.

At the initial testing session, the patient was given a verbal orientation and demonstration of the performance required. At least one practice trial was allowed before testing began. The amount and type of orientation allowed varied with the needs of the patient. The objective was to get the best estimate of the level of performance of which the patient was currently capable. On succeeding days, less orientation usually was required. In no case was data taken until the E was confident that the S understood and would cooperate.

In this connection, it was found best to encourage the patient to do his best work but also it was important to avoid any suggestion of pressure or competition. Best performance seemed to occur when the patient was alert but relaxed. Although both speed and precision were emphasized in the measures, this emphasis was not necessarily reflected in the performance of the patient. It has been our experience that when there is a conflict between speed and precision, the patients usually sacrificed speed in favor of precision. Hence the performance as measured here probably represents the more usual level of function of the patient rather than the absolute maximum performance of which he was capable.

For those interested in the apparatus, a complete wiring diagram and perspective drawings will be found in the appendix to this report.

Table 2.4 gives the essential data collection plan. The data collection session required about ten minutes for an experienced subject and about twice that for inexperienced or deteriorated subjects. There was little evidence that the S's were bored or generally slack, but it would be idle to assume that each S was performing at maximum capability during each session. It seems probable that the data represented a better approximation of the 'normal' operating level for the patient. While the S was encouraged and urged to do his best, it was found necessary to keep the 'pressure' down to avoid excessive disturbance of the subjects.

The data reported here were from the initial test experience, obtained either during the hospital-wide testing of resident patients or as soon as possible after the admission diagnosis.

Table 2.4

Data collection plan for the study.

Test	Unit	Duration or Number of Samples per Day
Reaction Time	.01 sec.	5 samples
Tapping	each	2 five-second samples
Serial Reaction Time	.01 sec.	Time to complete 20 responses; 5 samples, 1 on each sequence
Transport-Assembly	.01 sec.	Time to place 25 pegs, 1 sample

Chapter 3

DIAGNOSIS RELATED TO PSYCHOMOTOR PERFORMANCE

Before statistical treatment of the data was undertaken, an analysis was made of the relationship between the criterion measure, which was released or not released from the hospital within one year after testing (abbreviated hereafter as In/Out), and diagnostic category. The purpose of this analysis was to determine whether the diagnostic categories differed sufficiently in distribution on the criterion variable to cloud interpretation of statistical analysis.

From Table 3.1 it is evident that there is some relationship between diagnosis and outcome. Even allowing for the relatively small numbers in certain diagnostic categories, it seems quite evident that a fortuitous combination of circumstances could heavily weight the data. The alcoholic and psychoneurotic categories show a very high rate of discharge. If they also performed well (or even poorly) as a group on the psychomotor battery, the interpretation of the results on the other categories could be clouded.

The next step was to determine the relationship between diagnosis and psychomotor performance at a semi-quantitative level in order to check for this source of error. The determination was made for each test separately by arranging the scores in order of merit, dividing them into deciles of about 120 scores each and then categorizing them by diagnosis at each decile level. The results of this analysis combined across the five tests are presented in Table 3.2.

From this table it is immediately apparent that there is inequality of distribution. In fact only the two psychotic categories, schizophrenic and manic-depressive, approach an even distribution above and below the group median (upper limit of decile V). All other categories show about an 8:2 split at this point.

Table 3.1

The per cent of each diagnostic category classified as in or out of hospital following the twelve-month post-test period.

	Diagnosis						
	Schizophrenic	Manic Depressive	Chronic Brain Syndrome	Personality Disorder	Mentally Deficient	Psychoneurotic Reaction	Alcoholic
N	636	84	102	91	83	86	102
% In	43	17	80	26	91	5	0
% Out	57	83	20	74	9	95	100

Table 3.2

The per cent of each diagnostic category falling in the various deciles.

	Diagnosis						
Decile	Schizophrenic	Manic Depressive	Chronic Brain Syndrome	Personality Disorder	Mentally Deficient	Psychoneurotic Reaction	Alcoholic
X	8	8	2	27	0	19	20
IX	8	11	1	19	1	16	23
VIII	9	15	5	11	2	19	14
VII	9	12	6	13	2	13	16
VI	11	16	6	7	3	14	10
V	12	11	7	8	5	8	7
IV	12	12	11	6	8	4	5
III	12	7	16	4	15	4	4
II	12	4	20	2	20	2	1
I	8	3	27	2	41	0	0

The decision was made to discard from further analysis the psychoneurotic and alcoholic categories for the following reasons:

(1) There was a marked interaction between performance and outcome for both groups; both had more than 80% above the median and more than 95% out. Inclusion might well give rise to spurious accuracy when considering the diagnostic groups as a whole.

(2) There is little need for selecting from these groups for rehabilitation training since so high a percentage leaves the hospital without such training.

The same line of argument may be as legitimately applied to the mentally deficient category and, with lesser force, to the chronic brain syndrome and personality disorder groups. It was, however, decided to retain these groups primarily because they form a considerable fraction of the hospital population from which rehabilitation training candidates must be selected. While the chronic brain syndrome and mentally deficient groups have a relatively low rate of release, there is a continuing movement out of the hospital, and it is possible that more efficient selection procedures could increase this rate.

We may now proceed to a formal examination of the relationship between diagnostic category and psychomotor test performance. In accord with the previous decision the alcoholic and psychoneurotic groups were dropped from consideration. We also dropped all cases with incomplete score records. Thus the five diagnostic categories and the number of cases in each were:

Group No.	Diagnosis	N
1	Schizophrenic	636
2	Manic Depressive	84
3	Chronic Brain Syndrome	102
4	Personality Disorder	91
5	Mentally Deficient	83

Our test program was designed to yield five daily scores for each individual on each test. These five scores permitted us to use a repeated-measures analysis of variance model which, by fractioning the error term permitted a more sensitive F-test. The general statement of the model and its degrees of freedom appears below.

Source of Variance	df
Between Individuals	995
Groups	4
Subjects within Groups	991
Within Individuals	3984
Days	4
Days x Groups	16
Days x Subjects within Groups	3964

The results of this analysis of variance are briefly summarized in Table 3.3. The complete results are contained in the appendix.

Table 3.3

Summary of the analysis of variance results for the groups and days analysis. Cell entries are level of significance of the F-ratios for the combinations of tests and variance sources.

	Tests				
Source of Variance	Tapping	Reaction Time	Transport	Assembly	Serial Reaction Time
Groups	.01	.01	.01	.01	.01
Days	.01	.01	.01	.01	.01
Days x Groups	.01	NS	.01	.05	.01

Our initial attention must be given to the fact that four of the five interaction terms have a significant F-ratio. This indicates that certain combinations of days and groups interacted in a manner not wholly explicable from the days and groups main effects. Hence it is possible that the main effects may be significant largely due to this interaction. In statistical terms, a significant interaction clouds the interpretation of the main effects.

Investigation of this interaction was made by constructing figures showing performance as a function of days for all groups on each test. These figures are reproduced in Appendix I. It was quite evident that the interactions were due in the main to minor variations in the day-to-day performance. To summarize briefly:

(1) In no case did any curves cross, though in two instances they were virtually congruent.

(2) With only one exception, the groups maintained their hierarchial position from test to test.

(3) The vertical separation of the groups and the virtually universal (one obvious exception) improvement in performance as a function of daily testing make it abundantly clear that two significant main effects (days and groups) are in fact real and are not an artifact due to interactions.

Next we may turn to the analysis of the two main effects, groups and days. The effects for days is, of course, strictly a learning phenomenon, and we will dismiss it from further consideration on the grounds that the results conform to those of previous studies. It should be noted, however, that the slope of these curves varies with the different diagnostic groups, and it would be quite misleading to pool them into a single function. There is no learning curve for 'mental patients', a fact commented on elsewhere by King (1954).

The main effect for groups was significant at the .01 level for all five tests. This statement gives no indication of the magnitude of these differences. The observed F-ratios varied between 40 and 117 where a ratio of 3.35 is significant at the .01 level. In short, they were really different.

This brings up the question of who differs from whom and in what respect. An intuitive answer can be gained by inspection of the figures of Appendix I which shows performance as a function of days for each diagnostic group. There is really a wide range of performance among the groups, but the question of who differs from whom requires a statistical decision-making process. The appropriate technique for this analysis is the Newman-Keuls test of the significance of differences among ordered means. The results are presented in Table 3.4 which shows the significance level of the differences among the group means on all tests.

That table may be conveniently summarized by considering the presence or absence of significance and rearranging the sequence of groups into the order-of-merit sequence. The results are presented in Table 3.5.

From these tables it seems obvious that there were real and sizeable differences in performance among the diagnostic groups. There are ten comparisons within each test and five tests for a total of fifty comparisons. Of these, 31 were significantly different. The mentally deficient entered into 16 such comparisons, the chronic brain syndrome into 13, personality disorder into 12, schizophrenic into 11, and manic depressive into 10. (These figures sum to 2N = 62 since each comparison is counted once for each group.) Clearly, the mentally deficient group differed most often from all other groups. If we eliminate this group from further consideration for the moment, the maximum number of significant comparisons possible now becomes 6 x 5 tests = 30. Of these,

Table 3.4

Analysis of the significance of the differences among the means of the various diagnostic groups on each of the five tests. Cell entry is the level of significance. Group 1 = schizophrenic, 2 = manic depressive, 3 = chronic brain syndrome, 4 = personality disorder, 5 = mentally deficient.

	Tests																			
	Tapping				Reaction Time				Transport				Assembly				Serial Reaction Time			
Diagnostic Groups	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
1	05	-	01	05	-	-	05	05	-	01	-	01	-	01	-	01	-	05	-	01
2		01	-	01		-	-	01		01	-	01		01	-	01		01	-	01
3			01	-			05	01			01	-			01	-			01	-
4				01				01				01				01				01

Table 3.5

The frequency with which the various groups differed significantly from each other. Cell entries are the number of tests on which a significant difference was observed.

Diagnostic Groups	Manic Depressive	Schizophrenic	Chronic Brain Syndrome	Mentally Deficient
Personality Disorder	0	2	5	5
Manic Depressive	-	1	4	5
Schizophrenic		-	3	5
Chronic Brain Syndrome			-	1

15 were actually significant. The chronic brain syndrome group participated in 12 of these, personality disorder in 7, schizophrenic in 6, and manic depressive in 5. It seems fair to say that the mentally deficient and chronic brain syndrome groups accounted for the major share of the significant differences observed, yet only once was there a significant difference observed in five comparisons between these groups. Similarly the other three groups differed among themselves only three times in fifteen comparisons.

Of course, it is not particularly surprising to find that the chronic brain syndrome and mentally deficient patients should tend to differ from the other diagnoses more often than from each other, but it is much less expected that diagnostic groups as far apart in terms of degree of pathology as schizophrenic and personality disorder should not differ more widely than on two of five comparisons.

In summary, analysis of the significance of the difference among group means seems to indicate that the majority of the differences occurs between two groupings which may be loosely termed 'functional' (schizophrenic, manic depressive, and personality disorder) and 'organic' (mentally deficient and chronic brain syndrome). The matter of differential performance among the diagnostic categories will be considered again when the problem of cutting scores is discussed.

Chapter 4

PSYCHOMOTOR TESTS RELATED TO PATIENT OUTCOME: MULTIPLE REGRESSION AND MULTIPLE CORRELATION METHOD

This chapter concerns the ability of the tests to differentiate those patients who will leave the hospital from those who will not leave within the one-year observation period. Demonstration that there is such a differential performance must logically precede attempts to set up selection procedures.

The appropriate analysis of variance model for this problem is the p x q with repeated measures on the second factor. The model is identical to the one used in the preceding analysis except that the A factor now has two levels (in or out of hospital) instead of the five levels (diagnostic groups) as in the first analysis. The advantage of retaining this approach is that it divides the residual into two parts, thus increasing the sensitivity of the F-test. The model is shown in Table 4.1.

As may be seen from the table, there are three F-ratios for each group-test combination to be evaluated. The level of significance for each is reported in Table 4.2.

Of the results appearing in Table 4.2 only certain aspects will merit close attention. The Days main effect and the In/Out x Days interaction are essentially what has been seen in the previous analysis. The Days effect, significant in 22 of 25 instances, merely indicates learning during the course of the test administration, and the significant interaction term indicates that learning was not a constant for all days. It is noteworthy that there was no significant interaction in the chronic brain syndrome, mentally deficient, or personality disorder groups.

We are primarily interested in the In/Out main effect. Overall, this effect was significant in 20 of 25 instances with all five of the non-significant instances occurring in

Table 4.1

Model for analysis of variance used in investigation of relationship to outcome to psychomotor performance. Degrees of freedom vary with size of groups.

Source of Variation	Degrees of Freedom
Between Subjects	
Outcome	1
Subjects within Groups	(n-1 ins) + (n-1 outs)
Within Subjects	
Days	4
Days x Outcome	4
Days and Subjects within Groups	4 (n in + n out - 2)

Table 4.2

Summary of the significance of the F-ratios for the analysis of variance of outcome vs days. Cell entries are the significance level.

		Tests				
Group	Variance Source	Tapping	Reaction Time	Transport	Assembly	Serial Reaction Time
Schizo-phrenic	In/Out	01	01	01	01	01
	Days	01	01	01	01	01
	In/Out x Days	01	01	--	--	01
Manic De-pressive	In/Out	01	01	01	01	01
	Days	--	01	01	01	01
	In/Out x Days	--	--	01	01	01
Chronic Brain Syndrome	In/Out	01	05	01	01	05
	Days	01	01	01	01	01
	In/Out x Days	--	--	--	--	--
Person-ality Disorder	In/Out	01	01	01	01	01
	Days	01	01	01	01	01
	In/Out x Days	--	--	--	--	--
Mentally Deficient	In/Out	--	--	--	--	--
	Days	--	--	01	01	01
	In/Out x Days	--	--	--	--	--

the mentally deficient group. Only two of these twenty instances were significant at the lower .05 level. Both of these were in the chronic brain syndrome group, thus continuing the association of these groups previously found in the between-diagnostic-groups analysis reported in Chapter 3. A review of the 18 F-ratios involved showed them to be quite substantial, ranging from 8.24 to 167.14 where $F = 6.70$ is significant at the .01 level. We may conclude, therefore, that there exists a sufficiently substantial difference in performance between the 'in' and 'out' groups to warrant further investigation of the tests as a selection device.

There are a variety of approaches possible in the analysis of the tests as a selection device. We shall be concerned with two; the use of multiple cutting points and the analysis of regression. The first of these is a rather pragmatic cut-and-fit procedure, while the regression analysis is statistically more elegant, although there is no guarantee that the product will be superior.

The multiple regression and multiple correlation method of analysis is one of the more sophisticated statistical techniques applicable to the problem of determining the weights to be accorded to the various tests in a test battery. For those readers who are not acquainted with the method, we will attempt to develop a non-technical explanation which will give the reader an intuitive grasp of how the technique works.

The basic elements in this situation are the age and sex factors, the five psychomotor test scores, and the outcome for each individual. We will refer to the factors and the tests as predictor variables, and to the outcome as the criterion variable. The relationship between each predictor variable and the criterion variable is expressed by the coefficient of correlation which may have any value from -1.0 through zero to +1.0. Using these coefficients as input data and using the analysis of regression statistical technique, we can select a weighted combination of tests which will give us the best prediction of our criterion measure. The statistic called multiple correlation is now computed which measures the degree of relationship between our predicted results and what was actually observed.

To summarize briefly, we measure the relationship between each of our psychomotor tests and patient outcome, use these measures to select the best weighted combination of tests, use this combination to make predictions, and then measure the relationship between predicted and observed outcomes.

In this analysis we will use an approach developed in industrial psychology for evaluating selection procedures (Tiffin 1952). The method requires a large group of subjects for whom test scores and outcome data are available. The group is divided into a primary and a criterion group on some basis other than test scores or outcome. The selection procedures are then developed on the data for the primary group, endeavoring to select those measures which will best predict outcome. The combination of tests thus selected is now applied to the criterion group data and evaluated in terms of how well outcome was predicted.

The schizophrenic group was selected because it was the largest of the diagnostic groups and had the best balance between the 'in' and 'out' outcome classification. To form the 'primary' and 'criterion' sub-groups, the 636 cases were arrayed in order of age at testing and divided alternately into two groups of 318 cases each. Each sub-group was further divided into an 'in' and 'out' group on the basis of actual outcome. The characteristics of the groups thus formed are given in Table 4.3.

In this analysis we will use the schizophrenic primary group to obtain the test weights and then apply the weights to the data for the schizophrenic criterion group and see how well the predictions fit the actual outcome. Next we will apply them to the other diagnostic groups to see how well they work here. Finally we will pool all 996 cases, obtain

Table 4.3

The distributions of the primary and criterion groups with respect to outcome. Cell entries are the number of cases.

Group	Out	In	N
Primary	177	141	318
Criterion	186	132	318
Totals	363	273	636

regression weights based on the entire group, and examine accuracy of prediction among the various diagnoses.

In order to do this analysis, it will be remembered that we need the various correlations among the test scores and of the predictors with the criterion variable. The intercorrelation matrices are presented in the statistical supplement. Table 4.4 shows the correlation between predictor and criterion variables. Caution must be observed in interpreting the signs. In all of the psychomotor tests except rate of tapping, a low score is a good score. The code for 'in' and 'out' has the numerical value for 'out' greater than that for 'in'. Hence a negative correlation would be expected if goodness of performance is related to discharge. The negative sign for the age factor indicates that younger patients tend to get out more readily, an observation not at variance with common experience. The only exception to this rule is seen in the chronic brain syndrome group which has a positive correlation between age and discharge. Investigations indicated that this was due to minor fluctuations in small numbers. If we categorize age in five year intervals, the difference in number getting out between the intervals with the highest and lowest frequency is three patients.

Table 4.4

The correlation of each of the seven predictor variables with the criterion variable. The age factor, and all psychomotor tests except tapping, would be expected to have negative signs. All correlations significant at .01 level except * = .05 level and ___ indicates not significantly different from zero.

Groups	Predictor Variables						
	Sex	Age	Tapping	Reaction Time	Transport	Assembly	Serial Reaction Time
Schizophrenic Primary	.102	-.249	.327	-.403	-.345	-.391	-.345
Schizophrenic Criterion	.062	-.243	.402	-.503	-.281	-.399	-.386
Manic Depressive	.045	-.179*	.352	-.367	-.307	-.430	-.322
Chronic Brain Syndrome	.092	+.131	.322	-.211*	-.294	-.353	-.242*
Personality Disorder	.054	-.078	.426	-.330	-.432	-.532	-.563
Mentally Deficient	-.106	-.265*	.111	-.199	-.063	-.141	-.114
Total Group	.109	-.188	.441	-.436	-.409	-.403	-.412

All correlations are significantly different from zero at the .01 level except those marked with an asterisk which are significant at the .05 level and those underlined which are not significant.

It is instructive to note that the mentally deficient group differs markedly from the other diagnostic categories. It has the lowest correlations of any of the groups on the psychomotor tests. The difference is probably due to the marked imbalance between the numbers in the 'in' and 'out' groups. Only 8 of 83 patients in this group got out of the hospital during the year after test.

The following observations can be supported from observation of Table 4.4.

(1) The diagnostic groups characterized by brain dysfunction (chronic brain syndrome and mentally deficient) tend to have lower correlations of test scores with the criterion.

(2) The correlations involving age and sex tend to be lower than any of the other factors.

(3) Of the 14 correlations not significantly different from zero, 6 occur in one diagnostic group and the other 8 are found in the age and sex factors.

(4) Of the 35 correlations which are significantly different from zero, none account for the large share of the variance. It must be remembered, however, that the predictor variable is dichotomous while all others (except sex) are continuous, a situation which tends to hold down the size of the coefficients.

Table 4.5 presents the summarized results of the multiple correlation technique described previously. The first column

Table 4.5

The coefficient of multiple correlation for each diagnostic group under three conditions. (1) For each group individually based on own data, (2) for each group based on the weights for the schizophrenic primary group, (3) for each group based on the weights for the combined diagnoses.

Group	(1) Own Data	(2) Schizophrenic Primary Data	(3) Whole Group Data
Schizophrenic Primary	.4799	.4799	.4633
Schizophrenic Criterion	.5475	.5248	.5269
Schizophrenic Combined	-----	-----	.4942
Manic Depressive	.4817	.3999	.4171
Chronic Brain Syndrome	.4461	.3119	.3782
Personality Disorder	.5940	.5062	.5695
Mentally Deficient	.3083	.1810	.1714
Total Group	.5490	.5392	.5490

presents the correlation between predicted and actual outcome when the predictions were obtained from score weights computed for each group separately. The weights used are presented in the statistical supplement. All correlation coefficients are significantly different from zero except that for the mentally deficient group.

The second column shows the coefficients obtained when the weights found for the schizophrenic primary group are applied to the other groups. There was a substantial decline in the size of the coefficients except in the schizophrenic criterion group where the decline was negligible. These weights do well, as might be expected, for the schizophrenics but are markedly less successful when applied to the other diagnostic groups. It seems safe to conclude that the weights best for the schizophrenic group cannot be applied to the other diagnoses.

A third approach to the same problem was made by using the weights generated for the total group. The results are presented in Column 3. In most cases there is an increase in the size of the coefficient over that obtained when using the schizophrenic primary weights. One schizophrenic group exhibits a small decline, an observation which is quite predictable since the weights in the second column are based entirely on the schizophrenic segment of the group.

The table may best be summarized by saying that the reader must make his own decision whether to use the individual diagnostic group weights or the whole group weights. It is the bias of the writer that the increase in the coefficients obtained by using individual diagnostic group weights is of negligible value. The best measure of the difference is to square the coefficients to obtain the per cent of the variance accounted for by the correlation. This indicates, when using the whole group weights, an average decrement of four per cent with the maximum of seven per cent occurring in the mentally deficient group.

At this point in the analysis we are faced with the practical problem, to wit, is the technique possessed of sufficient accuracy to be practically worthwhile. The most satisfactory approach to this problem is to find out how well the technique can do at making individual predictions and then simply counting up successes and failures.

It will be remembered that the criterion variable was dichotomous, being coded as (1) for 'in' and (2) for 'out'. When the computer applied the weights to the obtained scores for each individual, it obtained a numerical value which was the predicted outcome for that person. These obtained values ranged from about .75 to 2.10. Values less than 1.501 were considered to be predicting an 'in' and values at or above that point to be making an 'out' prediction. The predicted outcome could then be compared to the actual outcome and the results tabulated in a four-fold table. Two categories, those where the predicted and actual outcomes agreed, can be counted as successes and the remaining two categories as failures. The results of this analysis are presented in Table 4.6. For ease in comparison, the results obtained by using predictions based on 'own-group' and 'whole-group' weights are shown in the same table.

There are several points of interest in Table 4.6. Primarily we are interested in the accuracy with which the tests can classify the individual patient. Inspection of the 'per cent correct' columns indicates that the tests do a highly satisfactory job of prediction. The values for all groups are sufficiently alike to make it clear that no one group accounts for a large share of the accuracy. While this point was not specifically tested, it seems clear that the between-group differences are probably not of practical importance.

Comparison of the two methods indicates a small difference in favor of using the weights obtained for each diagnostic group. However, it again seems clear that this difference is of no practical importance. Inspection of the totals indicates

Table 4.6

The accuracy of the prediction of outcome obtained by using 'own-group' and 'whole-group' score weights.

Group	N	Own-Group Weights Right	Own-Group Weights Wrong	Own-Group Weights % Correct	Whole-Group Weights Right	Whole-Group Weights Wrong	Whole-Group Weights % Correct
Schizophrenic	636	475	161	75%	469	167	74%
Manic Depressive	84	72	12	86%	72	12	86%
Chronic Brain Syndrome	102	81	21	79%	76	26	74%
Personality Disorder	91	74	17	81%	73	18	80%
Mentally Deficient	83	75	8	90%	65	18	83%
Totals	996	777	219	78%	755	241	76%

that 22 more patients are classified wrongly under the whole-group weights than under the individual-group method. A two per cent increase in accuracy is probably not worth the computer time involved.

At this point it may be well to pause for discussion of certain aspects. It takes no great amount of imagination to sense a certain amount of reader credulity about now. The per cent of correct classification or prediction seems a bit too good to be true. A critical check for possible sources of error is certainly indicated.

First, let us examine the data for internal consistency. The analysis of variance (Table 4.2) indicated a significant difference between the 'in' and 'out' groups in performance on all tests for all except the mentally deficient category. Turning to the coefficients of multiple correlation as reported in Table 4.5, the square of the whole-group coefficient, .5490, indicates that this correlation accounts for only 30 per cent of the total variance. This result appears at odds with the apparent accuracy of prediction reported above.

A bit of reflection provides a rational explanation. It will be remembered that we are predicting a dichotomous variable, 'in' or 'out' from a set of essentially continuous variables (test scores, age). But in order to make the prediction we were forced to dichotomize the continuous prediction variable about the arbitrary value of 1.500. Hence our per cent correct classification system ignores the variation within the groups thus created. The two sets of results thus are really not inimicable.

There is another source of error which must be considered. It is possible to obtain a correlation between two sets of data which is due largely to their individual relation to a third variable. Analysis of the methodology used in this study does not support any logical third-factor hypothesis. There was complete independence between the test scores and outcome criterion in the sense that the scores could not influence the outcome.

It has been suggested that a third factor is psychiatric status. This is plausible since it has been demonstrated (King 1954, Brooks and Weaver 1961) that psychomotor performance is positively related to psychiatric status and that the latter is obviously related to hospital discharge. However, the argument is quite circular since the 'in-out' criterion was chosen as the most reliable and objective measure of psychiatric status which was available on so large a group of patients. We believe that the measures and criterion were independent in fact and that the obtained relationships do not result for a fortuitious combination of circumstances.

Chapter 5

PSYCHOMOTOR TESTS RELATED TO PATIENT OUTCOME: MULTIPLE CUTTING POINT METHOD

The multiple cutting point procedure is also borrowed from industrial psychology. In this approach the test user usually has a formulated objective in the sense that he may wish to include or exclude a certain proportion of the group, or he may wish to maximize successful selections while minimizing unsuccessful selections. The point is that the cutting point selected must reflect the purpose of the user. Hence a wide variety of cutting points may be applied to the same score distribution.

In this chapter we shall use the same schizophrenic primary and criterion sub-groups as we described in the previous chapter. The data from the primary group will be used to develop a set of cutting points. These points will then be validated by applying them to the criterion group.

The analysis was begun by constructing score distributions for each group on each of the five tests. These distributions listed the frequency at each score interval for the 'in' and 'out' groups separately. A variety of approaches to selecting the "best" cut-off point were tried and discarded. An apparently promising method involved grouping the distributions into appropriate intervals, converting the N's for the 'in' and 'out' groups to per cent frequency, and then computing the difference in per cent on each interval. Presumably the interval with the greatest difference would be the location of the cutting point. The difficulty arose from the fact that the interval with the greatest difference is usually so far down the distribution than an unduly large portion of the 'in' group is above the cut-off point.

Reflection on the probable use of the test battery would appear to indicate that it would be most useful in arraying a group of potential rehabilitation candidates in terms of probability of release. The most usual danger to be avoided in these circumstances is the inclusion of too many potential 'ins' whose presence would tend to cut down on the productiveness of the program. Therefore, we have adopted, as a working hypothesis, a cut-off point which would include 67 per cent of the 'out' group. For convenience in exposition, cut-off points of 33 per cent and 50 per cent are included in the same table.

Table 5.1 represents a summary of the general outcome of this procedure. The table was constructed in the following manner. For each test, the score points which included 1/3, 1/2, and 2/3 of the 'out' sub-group of the primary group were determined. These same cut-off points were then applied to the data for the primary 'in' sub-group and to the criterion 'in' and 'out' sub-groups.

Several comparisons should be made in Table 5.1. First is the obvious difference between the primary 'out' and 'in' per cent at all levels of the five tests. The cut-off point of primary interest to us (67 per cent of the 'out' group) regularly includes about 1/3 of the 'in' group. We may conclude that there is sufficient agreement among the tests to make us confident of the reality of this result.

The next and crucial comparison involves the outcome of application of the cutting point to the independent criterion group. These data are reported in the two right-hand columns of Table 5.1 as per cent of the group above the cutting point. Within this group, comparison of the 'in' and 'out' sub-groups shows a highly satisfactory degree of separation, in fact, slightly better than was achieved with the primary sub-groups.

The degree of agreement between the primary and criterion groups is sufficient to warrant combining them. The results of the combination are reported in Table 5.2 which also contains an overall summary figure obtained by averaging across tests. This final figure is remarkably close to the desired cut-off proportions. It seems quite evident that the cut-off

Table 5.1

The effects of using cut-off points for 33%, 50%, and 67% of the primary 'out' sub-group on the primary 'in' sub-group and on the 'out' and 'in' sub-groups of the criterion group. Cell entries are per cent.

		Primary Group		Criterion Group	
		Out	In	Out	In
	N =	177	141	186	132
Tests	Cut-Off Score				
	33.60	33	18	24	13
Tapping	31.50	50	30	51	22
	28.80	67	38	69	33
	20.80	33	11	30	8
Reaction Time	23.80	50	18	55	17
	27.13	67	33	70	24
	25.65	33	9	29	10
Transport	28.27	50	23	47	17
	31.21	67	34	65	32
	35.69	33	13	31	14
Assembly	37.91	50	20	47	18
	42.66	67	32	71	31
	12.15	33	10	30	10
Serial Reaction Time	13.02	50	23	52	15
	14.16	67	41	68	33
		33	12	29	11
Averages		50	23	50	18
		67	36	69	31

Table 5.2

The per cent of the schizophrenic 'out' and 'in' groups lying above the three cut-off points for each of the five tests.

	Out %	In %
Tapping	28	16
	50	26
	68	36
Reaction Time	32	9
	52	18
	68	29
Transport	31	10
	48	20
	68	33
Assembly	32	14
	48	19
	69	31
Serial Reaction Time	32	10
	51	19
	67	37
Overall	31	12
	50	20
	68	33

points thus generated do an adequate job of differentiating the schizophrenic sub-groups. Obviously, other sets of cutting scores can be generated for specific purposes. The current ones appear to have some generality of application and serve as well for illustrative purposes.

The question of whether these standards developed on schizophrenics can be applied to other diagnostic categories as well is partially answered in Table 5.3 which shows the per cent of each diagnostic group scoring above the three cut-off points on each of the five tests. It must be remembered that the cut-offs were designed to yield about 1/3, 1/2, 2/3 of the schizophrenic group. In a real sense, the values of the schizophrenic 'out' group are the independent variable and all other values are dependent variables.

It is obvious by inspection that there is considerable group x test interaction. Certainly there is nothing like uniformity of selections within the various diagnostic categories. Nor is there any real reason why we should expect to find such uniformity. The analysis of variance previously showed that there were numerous significant between-groups differences with the chronic brain syndrome and mentally deficient groups usually being significantly poorer in performance. Hence a uniform cut-off score could hardly be expected to yield uniform proportions of the differing groups.

The data appears to support the following conclusions and implications.

(1) The cut-off points generated on the schizophrenic primary group did differentiate between the 'out' and 'in' outcome groups.

(2) These same cut-off points when applied to the schizophrenic criterion group were successful to about the same extent in differentiating between the 'out' and 'in' outcome groups.

Table 5.3

The per cent of each diagnostic group scoring above the three cut-off points on each test. Cut-off is expected per cent of the 'out' group; value of 'in' group is the dependent variable. Cut-off points were derived from values used on schizophrenic primary 'out' group to give indicated percentages.

		Diagnostic Groups									
		Schizo- phrenic		Manic De- pressive		Chronic Brain Syndrome		Person- ality Disorder		Mentally Deficient	
		362	273	69	14	21	81	67	24	8	75
Test	Cut-off	Out	In	Out	In	Out	In	Out	In	Out	In
Tapping	33	28	16	61	29	38	17	84	38	0	8
	50	50	26	75	43	48	18	93	42	12	9
	67	68	36	87	64	67	30	94	63	37	20
Reaction Time	33	32	9	57	21	38	20	94	71	25	7
	50	52	18	77	57	53	37	97	71	50	16
	67	68	29	85	71	77	49	99	79	75	27
Transport	33	31	10	26	7	10	1	40	17	0	4
	50	48	20	39	14	14	2	58	17	0	4
	67	68	33	49	29	24	2	72	25	12	7
Assembly	33	32	14	35	7	10	1	72	21	0	3
	50	48	19	48	7	14	4	81	29	0	4
	67	69	31	70	36	38	7	96	46	25	5
Serial Reaction Time	33	32	10	26	14	5	1	67	17	0	4
	50	51	19	62	36	19	10	90	33	12	7
	67	67	37	78	43	43	17	97	67	12	15

(3) Application of the cut-off points to patients of the other four diagnoses were less successful. This appears to be due in some measure to the variations in discharge rate within these diagnostic groups.

Chapter 6

CLINICAL APPLICATION OF TEST DATA

This chapter will be concerned with the specific applications of the test data to the individual patient, illustrating the manner in which the test data can be applied and interpreted. There are two basic approaches to the problem: interpretation through decile scores, and prediction of outcome through use of a weighted combination of test scores.

We will consider first the use of decile scores since it is the most straightforward and easiest to understand. The basic output of the test program is a set of scores for each patient. For our purposes it is immaterial whether these are the result of a single day of testing or the mean score across five days. All that is required is a set of numbers representing performance on each of the five tests.

The basic reference data are contained in Tables 6.1 through 6.5 in the columns headed 'Decile Limits'. These data will enable the user to place the score in the appropriate decile. The result is five decile scores. These may be averaged and considered as a single score or they may be considered individually if desired. If there is a wide scatter to the decile scores, it is probably inadvisable to average them.

The scores may be interpreted in a variety of ways. The decile furnishes information about the placement of the individual with regard to the performance of the whole group. A decile score of VIII indicates that the performance exceeds or equals that of 80 per cent of the group of approximately 1000 patients.

The tables can also be used to obtain an approximation to the probability of discharge. The tabular entries are in per cent cumulated from top to bottom. Either the columns for the appropriate diagnosis or for the whole group may be used,

Table 6.1

Decile limits and distribution of cases by diagnosis and outcome for the tapping test. Entries are cumulative per cent.

Deciles	Decile Limits	Schizo-phrenic		Manic De-pressive		Chronic Brain Syndrome		Person-ality Disorder		Mentally Deficient		Whole Group	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
X	51.50 - 40.30	3	11	7	23	1	10	21	40	1	0	4	16
IX	40.29 - 36.40	10	24	14	39	5	20	34	67	1	0	10	31
VIII	36.39 - 33.70	15	35	28	59	17	39	38	83	8	0	17	44
VII	33.69 - 31.70	26	49	35	75	18	44	42	92	9	13	24	57
VI	31.69 - 29.60	33	63	49	85	27	58	63	92	13	26	31	69
V	29.59 - 27.50	41	74	63	92	37	77	75	95	25	39	41	79
IV	27.49 - 25.00	52	84	70	98	51	82	83	98	40	52	53	87
III	24.99 - 22.00	66	92	91	99	60	96	87	100	59	77	67	94
II	21.99 - 17.50	84	98	91	100	78	96	100	100	74	90	83	98
I	17.49 - 05.90	100	100	100	100	100	100	100	100	100	100	100	100

Table 6.2

Decile limits and distribution of cases by diagnosis and outcome for the reaction time test. Entries are cumulative per cent.

Deciles	Decile Limits	Schizo-phrenic		Manic De-pressive		Chronic Brain Syndrome		Person-ality Disorder		Mentally Deficient		Whole Group	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
X	12.53 - 16.89	5	7	0	14	7	14	38	51	3	0	6	13
IX	17.00 - 18.86	8	19	14	38	12	24	55	78	6	12	10	28
VIII	18.87 - 20.86	13	32	21	55	21	38	72	94	7	24	16	42
VII	20.87 - 22.79	19	45	35	71	34	48	72	97	15	24	23	54
VI	22.80 - 24.86	27	60	64	77	41	67	72	97	19	61	31	66
V	24.87 - 28.46	36	74	71	86	52	77	80	98	30	74	40	77
IV	28.47 - 32.06	47	86	71	92	64	82	84	100	38	86	50	87
III	32.07 - 39.26	61	93	78	98	74	100	96	100	50	86	63	94
II	39.27 - 52.46	78	100	92	100	84	100	96	100	73	86	79	99
I	52.47 - 99.99	100	100	100	100	100	100	100	100	100	100	100	100

Table 6.3

Decile limits and distribution of cases by diagnosis and outcome for the transport test. Entries are cumulative per cent.

Deciles	Decile Limits	Schizo-phrenic		Manic De-pressive		Chronic Brain Syndrome		Person-ality Disorder		Mentally Deficient		Whole Group	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
X	16.23 - 22.95	5	15	7	16	0	0	8	25	1	8	4	16
IX	22.96 - 25.62	12	31	7	26	1	9	16	40	4	0	9	30
VIII	25.63 - 28.02	22	46	14	37	2	14	16	56	4	0	15	44
VII	28.03 - 30.34	30	61	21	47	2	23	24	68	7	13	21	58
VI	30.35 - 32.77	43	72	35	54	8	28	28	81	8	13	31	68
V	32.78 - 35.49	57	81	56	64	10	37	45	91	11	38	42	77
IV	35.50 - 38.93	69	88	56	81	24	61	74	95	15	38	53	86
III	38.94 - 45.20	80	95	70	94	42	70	79	98	32	51	66	94
II	45.21 - 56.64	94	100	77	97	60	79	92	100	60	64	83	98
I	56.65 - 99.99	100	100	100	100	100	100	100	100	100	100	100	100

Table 6.4

Decile limits and distribution of cases by diagnosis and outcome for the assembly test. Entries are cumulative per cent.

Deciles	Decile Limits	Schizo-phrenic		Manic De-pressive		Chronic Brain Syndrome		Person-ality Disorder		Mentally Deficient		Whole Group	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
X	21.76 - 30.68	5	11	7	20	0	0	8	45	0	0	4	16
IX	30.69 - 34.15	12	26	7	31	1	10	16	63	3	0	9	31
VIII	34.16 - 37.20	17	42	7	45	2	15	29	78	4	0	13	46
VII	37.21 - 40.23	22	57	21	55	6	34	33	93	5	25	18	61
VI	40.24 - 43.33	32	70	35	74	11	39	45	96	6	25	26	73
V	43.34 - 47.36	44	81	42	87	20	53	58	97	10	38	36	83
IV	47.37 - 53.42	57	91	63	94	30	67	83	97	14	38	48	91
III	53.43 - 65.10	74	97	70	97	45	77	87	100	29	63	63	96
II	65.11 - 87.53	90	100	84	100	66	100	91	100	53	63	81	99
I	87.54 - 99.99	100	100	100	100	100	100	100	100	100	100	100	100

Table 6.5

Decile limits and distribution of cases by diagnosis and outcome for the serial reaction time test. Entries are cumulative per cent.

Deciles	Decile Limits	Schizo-phrenic		Manic De-pressive		Chronic Brain Syndrome		Person-ality Disorder		Mentally Deficient		Whole Group	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
X	09.40 - 11.47	3	16	7	7	1	5	4	36	1	0	3	17
IX	11.48 - 12.08	9	29	7	24	1	5	17	64	2	0	8	32
VIII	12.09 - 12.62	16	41	28	44	6	10	21	80	6	0	14	45
VII	12.63 - 13.23	24	53	35	61	11	24	42	89	6	13	21	58
VI	13.24 - 13.92	35	64	42	74	15	43	55	96	14	13	30	69
V	13.93 - 14.91	46	73	71	85	25	62	76	99	22	26	41	78
IV	14.92 - 16.12	58	84	78	92	36	76	93	100	30	26	52	87
III	16.13 - 17.75	72	92	78	95	57	81	93	100	45	63	66	93
II	17.76 - 20.88	86	97	85	98	79	95	97	100	68	88	82	98
I	20.89 - 49.99	100	100	100	100	100	100	100	100	100	100	100	100

at the option of the user. In this connection it should be remembered that the diagnostic groups with smaller number of cases may show a relatively greater fluctuation in the per cent figures as the result of a small difference in numbers. In these cases, consideration of the whole-group data as well as the diagnostic-group data is recommended.

Let us consider an example as a means of illustrating how the tables may be used. Assume a score of 30.00 on the transport test for a patient diagnosed as 'personality disorder'. From Table 6.3, a score of 30.00 falls in Decile VII. For the whole-group data, the cumulative per cents for the 'in' and 'out' groups are 21 per cent and 58 per cent respectively. For the 'personality disorder' diagnosis, the same values are 24 per cent and 68 per cent. Since there is little difference between the two sets of values, the same interpretation would hold for both. There are about two chances in ten that the individual would fall in the 'in' group and about six in ten of falling in the 'out' group. Since the score itself falls near the upper limit of Decile VII, the above probabilities are somewhat conservative.

To further elaborate the process, we will examine in detail the data obtained on one of our cases. This randomly chosen example was a male schizophrenic, 20 years old at testing, who was out of the hospital by the end of the observation period. For convenience, the data will be arranged in tabular form.

Test	Score	Decile	Schizophrenic Out	Schizophrenic In	Whole Group Out	Whole Group In
Tapping	31.40	VII	5/10	2/10	6/10	2/10
Reaction Time	23.80	VI	6/10	3/10	7/10	2/10
Transport	25.40	IX	3/10	1/10	3/10	1/10
Assembly	42.27	VI	7/10	3/10	7/10	3/10
Serial Reaction Time	13.09	VII	5/10	2/10	6/10	2/10
Average		VII	5/10	2/10	6/10	2/10

These figures may be evaluated by inspection. For the schizophrenic data, there are about five or six chances in ten that the individual is in the 'out' group and two or three chances in ten of being in the 'in' group. Since these 'probability' figures are computed for each group separately, they need not account for ten chances in ten. Essentially the same comments apply to the 'whole group' data.

Care must be taken in the interpretation of these probability figures. In reality, they are based on the fact that the 'out' group is much more heavily represented in the upper deciles than the 'in' group. As the middle and lower deciles are approached, the discrimination becomes much poorer. The prediction value is largely based on the difference between the cumulative per cent figures for each decile. While this forms an obvious limitation on the use of the tests, the practical difference is of considerably lesser importance. Generally speaking, we are interested in selecting those patients best able to profit from training. For the most part, these will be found in deciles VI - X where the discrimination is relatively satisfactory.

In short, we feel that this approach offers a useful tool to the clinician which will permit him to make an intuitive estimate of the patient's performance with reference to two sets of standards. It is not offered as a research-quality technique which will permit a definite prediction for each patient.

There is another approach which will permit a definite -- though not necessarily more accurate -- prediction for each patient. It will be remembered from the material presented in Chapter 4 on multiple regression and multiple correlation that the process was based on selecting the best combination of weighted test scores. The output of the process was a number ranging from slightly less than 1 to slightly more than 2. These predictions were interpreted as indicating an 'in' prediction when falling at or below 1.50 and as an 'out' for all values above that point.

The equation from which the prediction is made consists of a constant to which is added algebraically the product of the test scores multiplied by the calculated b-weights. The values for the various constants and b-weights for the various groups and test combinations will be found in the appendix. To illustrate the method, we shall use the set of weights obtained when the five psychomotor test scores are used as predictors. The test scores used are those which were used in the discussion of the decile score technique. The general form of the equation is given below.

Prediction = A (constant) + B_1 (tapping) + B_2 (reaction
time) + B_3 (transport) + B_4 (assembly) +
B_5 (serial reaction time)

Inspection of the values from the appendix makes it clear that the numbers are not adapted for easy handling. Due to the necessity for making the predicted value not exceed a value much greater than 2.0, the b-weights have significant values in the sixth decimal place. To further complicate matters, the computer program for this analysis treated all score values as if they were whole numbers. Consequently, in the computation of the prediction, decimals in the score values must be omitted. As will be seen in the following example, it is most convenient to move the decimal point in the constant and b-weights six places to the right before beginning computations and then, when the arithmetical operations are finished, to move it back six places to the left. We will illustrate the computation by both methods. It should be noted that the b-weights have algebraic signs which must be taken into account in the computations.

Test	Score	b-weight	+	-
Tapping	3140	.000078	.244920	
Reaction Time	2380	-.000045		.107100
Transport	2540	.000016	.040640	
Assembly	4227	-.000089		.376203
Serial Reaction Time	1309	-.000023		.030107
Totals			.285560	.513410

1.860000 + .285560 - .513410 = 1.632150 (Prediction)

In this example, the obtained value exceeds 1.500 and thus (correctly) predicts an 'out'. If it is desired to avoid the rather cumbersome decimal calculations, we can move the decimal point six places to the right in the A value and b-weights. This results, in the instance above, in the disappearance of the decimals in all the computations. In the final value, the point would follow the terminal zero. As the last operation the point is moved six places to the left and the value obtained in the original solution reappears.

So long as the operator takes due care with the signs and decimal points, the operation is quite simple and straightforward. Use of a desk calculator permits direct solution of the equation through positive and negative multiplication operations.

The question of which system is better or more useful is one which must depend upon the user for determination. Both methods will produce valid and useful information. However, it cannot be emphasized too often that these tests measure only one aspect of an essentially complex situation. The final judgment must rest on the shoulders of the skilled clinician.

We wish to enter a precautionary word about confusing mathematics with precision. The fact that the b-weight technique may give rise to an answer mathematically correct to the sixth decimal place does not imply a validity of equal precision. This means that the predicted value should not, when other factors are judged favorable, be allowed to function as an absolute bar to selection. This is particularly true of the mid-range values near the cut-off point of 1.500. While we have not been able to develop a satisfactory measure of reliability for our prediction number, it is highly probable that there is no significant difference between a value of 1.49 and 1.51. We recommend that in all borderline cases the patient be given the benefit of the doubt.

Chapter VII

DISCUSSIONS AND IMPLICATIONS

The implications of the foregoing body of data will be discussed under two aspects, practical and theoretical. The major portion of the discussion will be devoted to the first aspect.

In our view, these tests have two primary applications. One is to enable an administrator to arrange a group of patients in the order of readiness for rehabilitation training, a type of problem frequently encountered in organizing or expanding a rehabilitation program. The other application is to enable a clinician to evaluate the performance of a patient either with respect to local performance norms or with respect to the norms contained in this report.

The first application mentioned, that of group ordering, is probably the most important use of these tests. It is important that the selection of patients for rehabilitation training, particularly in a mental hospital where the supply of candidates may far outstrip the number of available program spaces, be conducted so as to select patients with a high probability of success and avoid the slower-moving patient who may require a much longer time to get through the program. Depending upon the relation between supply and capacity, the selection system may be as strict or as lenient as the user deems advisable.

Candidates for rehabilitation could be selected so as to insure the early and continuing success of a program, thus maximizing the morale of both the patients and the rehabilitation team. They could be used to divide a population of patients into groups which would need brief training and which would need more prolonged programs. They could also be used to eliminate the least hopeful cases and those for whom little or no rehabilitation effort would be needed.

Through differential consideration of the individual test scores, they should also prove very useful in selecting patients who would be capable of work requiring fine finger dexterity and those who should be trained for tasks requiring only more gross movements.

A word of caution and clarification should be inserted into the discussion at this point. It must be emphasized that these tests are an adjunct to and not a substitute for clinical judgment. They cannot be used for diagnostic purposes. Despite the significant differences among the diagnostic groups which have been demonstrated, the tests are completely unable to distinguish, for example, between a phobic personality disorder and a potentially dangerous paranoid schizophrenic. Indeed, it is quite probable that both would achieve scores which would indicate high potential for rehabilitation. The differentiation of these conditions is the task of the clinician and not that of the psychomotor test technician.

What these tests can do in the clinical situations is to suggest an order of consideration. If the program of testing is hospital-wide so that data are available on all patients, the population may be screened for high-scoring patients who have not been considered for inclusion in the rehabilitation program. It is not unusual for the quiet, well-behaved patient to be overlooked. In the course of this study we located about half-a-dozen such patients who were then recommended for consideration. Almost all of this group have subsequently left the hospital. We feel that the degree of contamination of our data, less than one per cent, could be accepted in view of the other benefits involved.

Also pertinent in this regard is the question of the extensiveness of a testing program. It is recommended that a hospital-wide program be given serious considerations if a rehabilitation effort of some magnitude is contemplated. This approach not only furnishes the maximum amount of information but also facilitates the development of a local set of norms on the tests. While we have reason to doubt that these norms would differ materially from those presented herewith, their presence would lend confidence to the interpretation of performance data. However, when a program involving only a small number of patients relative to the hospital population is to be undertaken, the more extensive program would probably not be justified. It would be desirable, however, to test all patients who were considered eligible for training in order to obtain as broad a sample as possible from which to select.

The second area of application is that of the evaluation of the individual patient where large-scale testing is not to be accomplished. This situation provides several limitations on the use of the tests. The user must depend, at least initially, on the norms published herewith. This implies that the tests to be used are substantially the same as those used in this study if validity is to be preserved. Elsewhere in this report are detailed specifications of the physical size and arrangement of the test apparatus. We cannot specify that some or any of these details and specifications are critical but the user who departs from them materially does so at an unknown degree of risk.

Assuming a substantial replication of the test situation and procedures, the user can compute the mean performance on each test and refer it to the decile limits as contained in Tables 6.1 to 6.5. Based on this information, he can then place the patient with reference to the appropriate group and determine the per cent of people with similar scores who left or remained in the hospital. From this point on the clinician is on his own in solving the complex equation of factors presented by the individual patient. We do not feel that a low score should always serve as an absolute bar to rehabilitation training but the clinician must be prepared to accept the probable consequences of such a selection. Each user must assay his local situation and make his decision accordingly.

In this connection, it is important to take cognizance of the currency of the test data. We have previously remarked that we feel the test performance is strongly related to psychiatric status. It is not unusual for this status to change (else there would be little point to therapeutic effort), sometimes with considerable celerity. Where there is doubt as to whether the test results accurately reflect the current status of the patient, a re-test is certainly in order. Re-testing at intervals should help to indicate which patients are responding to adequate treatment and which need some change in management. The tests may also be of assistance in making the sometimes painful decision to terminate the rehabilitation program of a patient as not presently feasible.

The theoretical implications of these data are markedly less obvious than the practical ones. There are, nonetheless, certain elements which seem to fit together and which appear to have certain theoretical aspects. We shall briefly restate certain points to insure a common ground for discussion.

In the previously cited Columbia-Greystone project report (1949), King observed that, following prefrontal lobotomy, the psychomotor test items showed improvement in performance before there was any evidence of clinical improvement. The post-operative period was marked by a considerable decrement in all forms of behavior and the psychomotor test items provided the first index of recovery. From this we infer a relationship between psychomotor performance and the functional state of the brain during its recovery from cerebral insult.

The second point is the monograph by King (1954) which examines the experimental evidence regarding the relationship between psychomotor impairment and severity of mental disease. He demonstrated clearly that there was a direct relationship between amount of impairment and rated severity of mental disease. Work in our own laboratory (Weaver 1961) confirmed King's findings to a degree limited only by the commonality of the two experimental situations. On the basis of these results, we cannot exclude the possibility that the mental disease process is due to interference with normal cerebral function by some unspecifiable condition or agent.

The third point is the demonstration (Brooks and Weaver 1961) that substitution of placebo for active tranquilizing medication results in decrement in both the psychomotor test performance and psychiatric status of the patient. In both the deterioration and the recovery following restoration of tranquilizing medication phases, the changes in test performance preceded the clinically observable behavior changes. Since it seems generally agreed that tranquilizing medication has a central rather than a peripheral locus of agent, we again infer that the psychomotor test results reflect the state of the cerebral function.

The implication which we draw from these lines of evidence and from the present study is that we can conceive of mental disease as a process usually characterized by three phases; (1) onset, with concurrent decrement in the adequacy of behavior, (2) illness, with continued impairment of function, and (3) recovery, during which there is improvement in function. This improvement may be spontaneous or influenced by tranquilizing medication.

The mode of action of the psychomotor test would thus appear to be the measurement of the central state of the nervous system. Since the clinically observable behavioral change appears to lag substantially behind the changes in the psychomotor test performance, the result is that the psychomotor test results tend to predict the behavioral changes.

This theoretical account of the method by which the psychomotor tests operate is advanced as the most straightforward account which we can give in the process as we understand it. It does not attempt to shed new light on the schizophrenic process (whatever that may be) other than to insist that the process has its locus of action in the brain and that such modifications of the process as can presently be effected are accomplished in the same organ.

Whether or not this explanation is accepted is really not germane to the issue of this report. By whatever method it is accomplished, the psychomotor tests do differentiate substantially between those who get out of the hospital and those who remain. The application of this information need not wait upon a universally accepted theoretical account of why things are as they are.

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APPENDIX

Table A-1

Intercorrelations among the various predictors and outcome for the total group.

	Age	Tapping	Reaction Time	Transport	Assembly	Serial React. Time	In/Out
Sex	.101	-.091	.119	-.040	-.009	.020	.109
Age		-.232	.362	.208	.305	.270	-.188
Tapping			-.632	-.518	-.622	-.604	.441
Reaction Time				.496	.576	.645	-.436
Transport					.847	.635	-.409
Assembly						.619	-.493
Serial Reaction Time							-.412

Table A-2

Intercorrelations among the various predictors and outcome for the schizophrenic primary group.

	Age	Tapping	Reaction Time	Transport	Assembly	Serial React. Time	In/Out
Sex	.077	-.090	-.031	-.056	.018	.000	.102
Age		-.233	.319	.240	.317	.287	-.249
Tapping			-.629	-.408	-.521	-.597	.327
Reaction Time				.529	.576	.719	-.403
Transport					.788	.534	-.345
Assembly						.496	-.391
Serial Reaction Time							-.345

Table A-3

Intercorrelations among the various predictors and outcome for the schizophrenic criterion group.

	Age	Tapping	Reaction Time	Transport	Assembly	Serial React. Time	In/Out
Sex	.152	-.138	.017	.062	.096	.118	.062
Age		-.238	.384	.210	.350	.281	-.243
Tapping			-.622	-.436	-.575	-.542	.402
Reaction Time				.418	.543	.597	-.503
Transport					.760	.457	-.281
Assembly						.467	-.399
Serial Reaction Time							-.386

Table A-4

Intercorrelations among the various predictors and outcome for the manic depressive group.

	Age	Tapping	Reaction Time	Transport	Assembly	Serial React. Time	In/Out
Sex	-.089	-.234	.195	.043	.062	-.079	-.045
Age		-.145	.299	.304	.324	.298	-.179
Tapping			-.537	-.565	-.654	-.529	.352
Reaction Time				.601	.629	.562	-.367
Transport					.901	.624	-.307
Assembly						.664	-.430
Serial Reaction Time							-.322

Table A-5

Intercorrelations among the various predictors and outcome for the chronic brain syndrome group.

	Age	Tapping	Reaction Time	Transport	Assembly	Serial React. Time	In/Out
Sex	.170	-.124	.208	.078	.120	.095	.092
Age		-.122	.275	.113	.183	.179	.131
Tapping			-.594	-.612	-.658	-.522	.322
Reaction Time				.609	.520	.656	-.211
Transport					.860	.732	-.294
Assembly						.639	-.353
Serial Reaction Time							-.242

Table A-6

Intercorrelations among the various predictors and outcome for the personality disorder group.

	Age	Tapping	Reaction Time	Transport	Assembly	Serial React. Time	In/Out
Sex	-.027	-.197	.073	.082	.078	.017	.054
Age		.008	.328	.130	.153	.289	-.078
Tapping			-.528	-.554	-.566	-.548	.426
Reaction Time				.415	.466	.411	-.330
Transport					.884	.640	.432
Assembly						.659	-.532
Serial Reaction Time							-.563

Table A-7

Intercorrelations among the various predictors and outcome for the mentally deficient group.

	Age	Tapping	Reaction Time	Transport	Assembly	Serial React. Time	In/Out
Sex	.094	-.241	.106	.080	.047	.193	-.106
Age		-.199	.497	.320	.492	.226	-.265
Tapping			-.449	-.490	-.513	-.577	.111
Reaction Time				.448	.573	.413	-.199
Transport					.750	.606	-.063
Assembly						.582	-.141
Serial Reaction Time							-.114

Table A-8

Decile limits and distribution of cases by diagnosis and outcome for the tapping test. Entries are number of cases.

Deciles	Decile Limits	Schizophrenic		Manic Depressive		Chronic Brain Syndrome		Personality Disorder		Mentally Deficient		Whole Group	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
X	51.50 - 40.30	9	39	1	16	1	2	5	27	1	0	17	84
IX	40.29 - 36.40	20	46	1	11	3	2	3	18	0	0	27	77
VIII	36.39 - 33.70	13	41	2	14	10	4	1	11	5	0	31	70
VII	33.69 - 31.70	29	50	1	11	1	1	1	6	1	1	33	69
VI	31.69 - 29.60	18	51	2	7	7	3	5	0	3	1	35	62
V	29.59 - 27.50	23	41	2	5	8	4	3	2	9	1	45	53
IV	27.49 - 25.00	31	36	1	4	11	1	2	2	11	1	56	44
III	24.99 - 22.00	39	31	3	1	7	3	1	1	14	2	64	38
II	21.99 - 17.50	48	21	0	1	15	0	3	0	11	1	77	23
I	17.49 - 05.90	43	7	1	0	18	1	0	0	20	1	82	9
	N =	273	363	14	70	81	21	24	67	75	8	467	529

Table A-9

Decile limits and distribution of cases by diagnosis and outcome for the reaction time test. Entries are number of cases.

Deciles	Decile Limits	Schizo-phrenic		Manic De-pressive		Chronic Brain Syndrome		Person-ality Disorder		Mentally Deficient		Whole Group	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
X	12.53 - 16.89	13	24	0	10	6	3	9	34	2	0	30	71
IX	17.00 - 18.86	7	43	2	17	4	2	4	18	2	1	19	81
VIII	18.87 - 20.86	13	48	1	12	7	3	4	11	1	1	26	75
VII	20.87 - 22.79	16	48	2	11	11	2	0	2	6	0	35	63
VI	22.80 - 24.86	23	53	4	5	6	4	0	0	3	3	36	65
V	24.87 - 28.46	24	50	1	6	9	2	2	1	8	1	44	60
IV	28.47 - 32.06	29	44	0	4	10	1	1	1	6	1	46	51
III	32.07 - 39.26	39	27	1	4	8	4	3	0	9	0	60	35
II	39.27 - 52.46	47	25	2	1	8	0	0	0	17	0	74	26
I	52.47 - 99.99	62	1	1	0	12	0	1	0	21	1	97	2
	N =	273	363	14	70	81	21	24	67	75	8	467	529

Table A-10

Decile limits and distribution of cases by diagnosis and outcome for the transport test. Entries are number of cases.

Deciles	Decile Limits	Schizo-phrenic		Manic De-pressive		Chronic Brain Syndrome		Person-ality Disorder		Mentally Deficient		Whole Group	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
X	16.23 - 22.95	13	55	1	11	0	0	2	17	1	0	17	83
IX	22.96 - 25.62	19	57	0	7	1	2	2	10	2	0	24	76
VIII	25.63 - 28.02	26	53	1	8	1	1	0	11	0	0	28	73
VII	28.03 - 30.34	23	54	1	7	0	2	2	8	2	1	28	72
VI	30.35 - 32.77	36	40	2	5	5	1	1	9	1	0	45	55
V	32.78 - 35.49	39	32	3	7	2	2	4	7	2	2	50	50
IV	35.50 - 38.93	32	27	0	12	11	5	7	3	3	0	53	47
III	38.94 - 45.20	29	26	2	9	15	2	1	2	13	1	60	40
II	45.21 - 56.64	38	17	1	2	15	2	3	0	21	1	78	22
I	56.65 - 99.99	18	2	3	2	31	4	2	0	30	3	84	11
	N =	273	363	14	70	81	21	24	67	75	8	467	529

Table A-11

Decile limits and distribution of cases by diagnosis and outcome for the assembly test. Entries are number of cases.

Deciles	Decile Limits	Schizo-phrenic		Manic De-pressive		Chronic Brain Syndrome		Person-ality Disorder		Mentally Deficient		Whole Group	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
X	21.76 - 30.68	14	39	1	14	0	0	2	30	0	0	17	83
IX	30.69 - 34.15	18	55	0	8	1	2	2	12	2	0	23	77
VIII	34.16 - 37.20	15	59	0	10	1	1	3	10	1	0	20	80
VII	37.21 - 40.23	15	55	2	7	3	4	1	10	1	2	22	78
VI	40.24 - 43.33	28	46	2	13	4	1	3	2	1	0	38	62
V	43.34 - 47.36	32	40	1	9	7	3	3	1	3	1	46	54
IV	47.37 - 53.42	36	36	3	5	8	3	6	0	3	0	56	44
III	53.43 - 65.10	46	21	1	2	12	2	1	2	11	2	71	29
II	65.11 - 87.53	45	10	2	2	17	5	1	0	18	0	83	17
I	87.54 - 99.99	24	2	2	0	28	0	2	0	35	3	91	5
	N =	273	363	14	70	81	21	24	67	75	8	467	529

Table A-12

Decile limits and distribution of cases by diagnosis and outcome for the serial reaction time test. Entries are number of cases.

Deciles	Decile Limits	Schizo-phrenic		Manic De-pressive		Chronic Brain Syndrome		Person-ality Disorder		Mentally Deficient		Whole Group	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
X	09.40 - 11.47	9	59	1	5	1	1	1	24	1	0	13	89
IX	11.48 - 12.08	17	48	0	12	0	0	3	19	1	0	21	79
VIII	12.09 - 12.62	18	45	3	14	4	1	1	11	3	0	29	71
VII	12.63 - 13.23	22	45	1	12	4	3	5	6	0	1	32	67
VI	13.24 - 13.92	29	40	1	9	3	4	3	5	6	0	42	58
V	13.93 - 14.91	29	33	4	8	8	4	5	2	6	1	52	48
IV	14.92 - 16.12	32	41	1	5	9	3	4	0	6	0	52	49
III	16.13 - 17.75	37	28	0	2	17	1	0	0	11	3	65	34
II	17.76 - 20.88	38	19	1	2	18	3	1	0	17	2	75	26
I	20.89 - 49.99	42	5	2	1	17	1	1	0	24	1	86	8
	N =	273	363	14	70	81	21	24	67	75	8	467	529

Table A-13

Analysis of variance for the diagnostic groups by days analysis of the tapping test data.

Source of Variance	Sums of Squares	Degrees of Freedom	Mean Square	F-ratio
Between Subjects		995		
Groups	755,915,013.14	4	188,978,753.28	65.72 **
Subjects within Groups	2,849,474,437.30	991	2,875,352.61	
Within Subjects		3984		
Days	5,427,569.58	4	1,356,892.39	14.977 **
Groups x Days	5,147,331.88	16	321,708.24	3.551 **
Days x Subjects within Groups	359,121,116.20	3964	90,595.63	

Table A-14

Analysis of variance for the diagnostic groups by days analysis of the reaction time test data.

Source of Variance	Sums of Squares	Degrees of Freedom	Mean Square	F-ratio
Between Subjects		995		
Groups	1,903,757,881.87	4	475,939,470.46	39.55 **
Subjects within Groups	11,924,805,438.10	991	12,033,103.36	
Within Subjects		3984		
Days	61,900,014.41	4	15,475,003.60	37.98 **
Groups x Days	10,221,899.60	16	638,868.72	1.5679 ns
Days x Subjects within Groups	1,615,194,303.60	3964	407,465.76	

Table A-15

Analysis of variance for the diagnostic groups by days analysis of the transport test data.

Source of Variance	Sums of Squares	Degrees of Freedom	Mean Square	F-ratio
Between Subjects		995		
Groups	3,202,513,850.13	4	800,628,462.53	101.36 **
Subjects within Groups	7,827,895,985.00	991	7,898,986.86	
Within Subjects		3984		
Days	98,448,347.32	4	24,612,086.83	121.72 **
Groups x Days	21,246,697.08	16	1,327,918.56	6.567 **
Days x Subjects within Groups	801,531,579.10	3964	202,202.71	

Table A-16

Analysis of variance for the diagnostic groups by days analysis of the assembly test data.

Source of Variance	Sums of Squares	Degrees of Freedom	Mean Square	F-ratio
Between Subjects		995		
Groups	6,616,567,278.84	4	1,654,141,819.71	116.56 **
Subjects within Groups	14,063,681,901.00	991	14,191,404.54	
Within Subjects		3984		
Days	237,390,523.37	4	59,347,630.84	188.26 **
Groups x Days	9,262,499.37	16	578,906.21	1.84 **
Days x Subjects within Groups	1,249,623,184.00	3964	315,242.98	

Table A-17

Analysis of variance for the diagnostic groups by days analysis of the serial reaction time test data.

Source of Variance	Sums of Squares	Degrees of Freedom	Mean Square	F-ratio
Between Subjects		995		
Groups	201,234,101.71	4	50,308,525.42	57.10 **
Subjects within Groups	873,196,366.10	991	881,126.50	
Within Subjects		3984		
Days	19,525,336.34	4	4,881,334.08	233.63 **
Groups x Days	3,465,987.55	16	216,624.22	10.37 **
Days x Subjects within Groups	82,822,618.80	3964	20,893.69	

Table A-18

The values for the A (constant) and b-weights for the various groups and tests combinations.

		B-weights						
Components	A	Sex	Age	Tapping	Reaction Time	Trans- port	Assembly	Serial Reaction Time
5 PM Whole Group Weights	1.8600	------	------	.000078	-.000045	.000016	-.000089	-.000023
7 Variables Whole Group b-weights	1.6282	.124800	-.000316	.000091	-.000043	.000020	-.000088	-.000029
Schizophrenic Primary Own Weights	1.9518	.113100	-.004728	.000048	-.000050	-.000014	-.000055	-.000047
Schizophrenic Criterion Own Weights	1.9544	.112100	-.001872	.000056	-.000098	.000040	-.000057	-.000133
Manic Depressive Own Weights	2.1113	.017510	-.001157	.000045	-.000079	.000165	-.000178	-.000030
Chronic Brain Syndrome Own Weights	1.0213	.110900	.006629	.000070	-.000022	.000042	-.000075	-.000026
Personality Disorder Own Weights	2.9291	.087320	.003313	.000058	-.000042	.000123	-.000174	-.001033
Mentally Deficient Own Weights	1.3728	-.039730	-.005405	.000010	-.000012	.000016	-.000002	-.000028

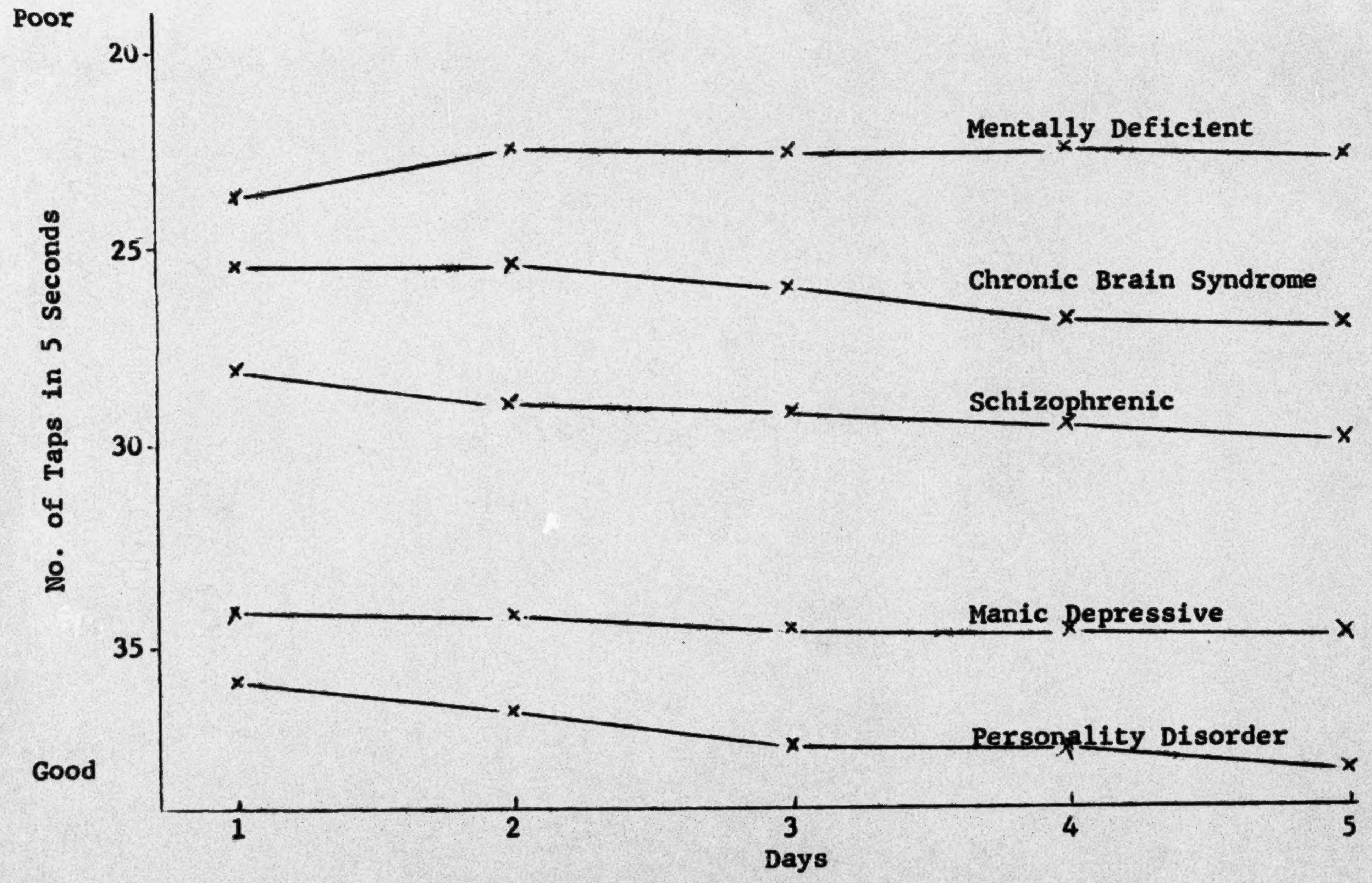


Figure A-1 The mean performance on the tapping test on each day for the five diagnostic groups.

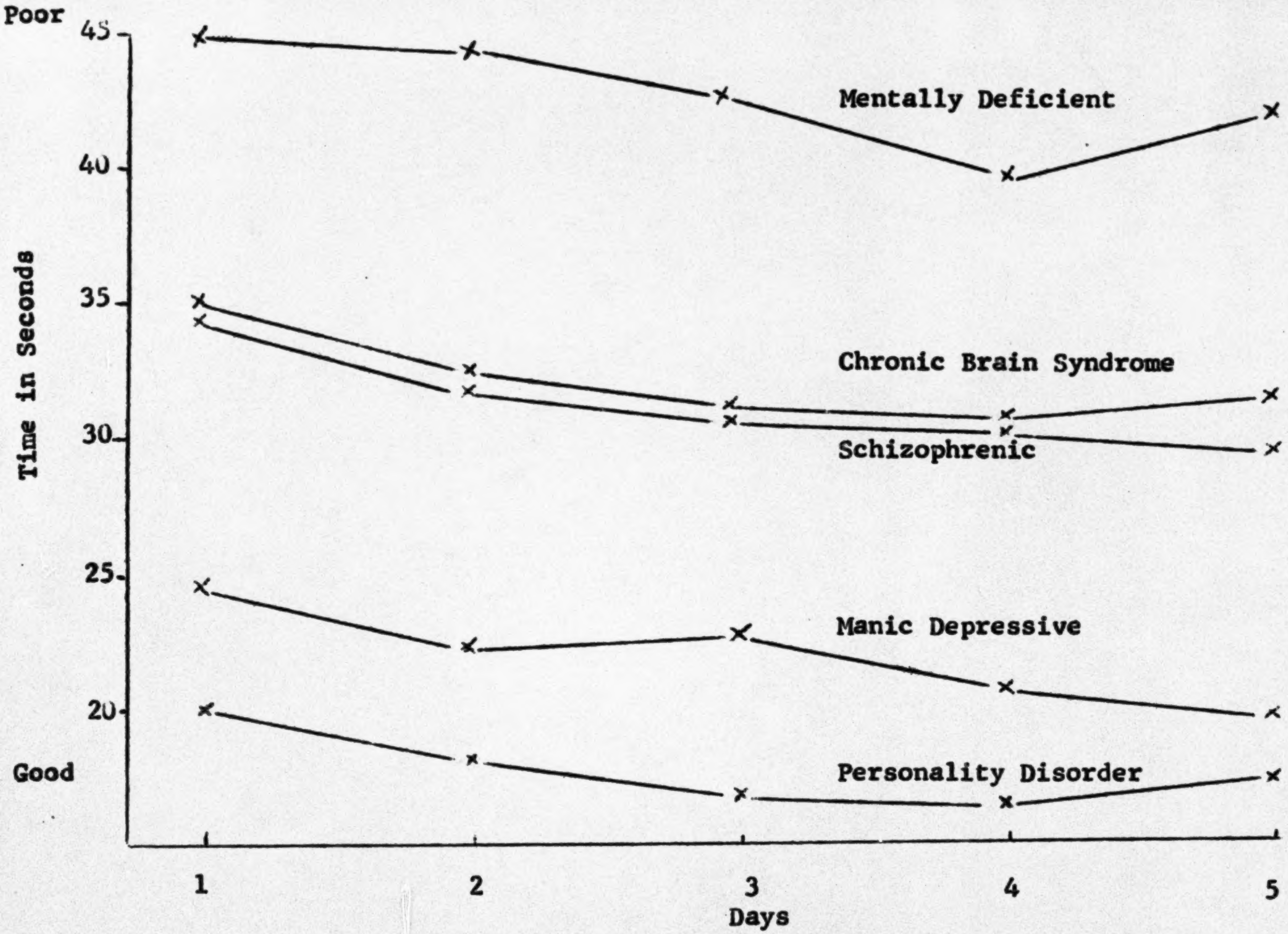


Figure A-2 The mean performance on the reaction time test on each day for the five diagnostic groups.

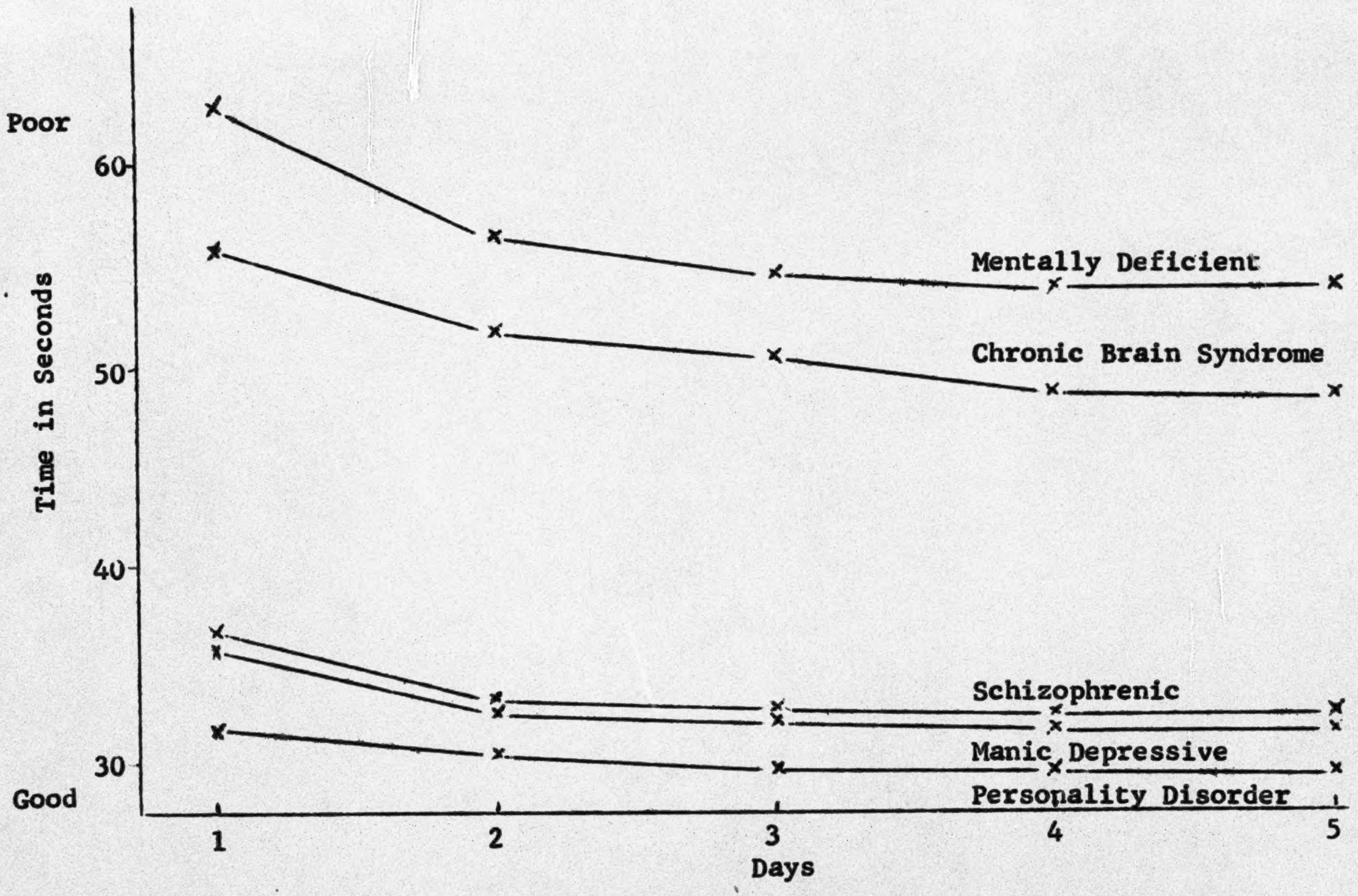


Figure A-3 The mean performance on the transport test on each day for the five diagnostic groups.

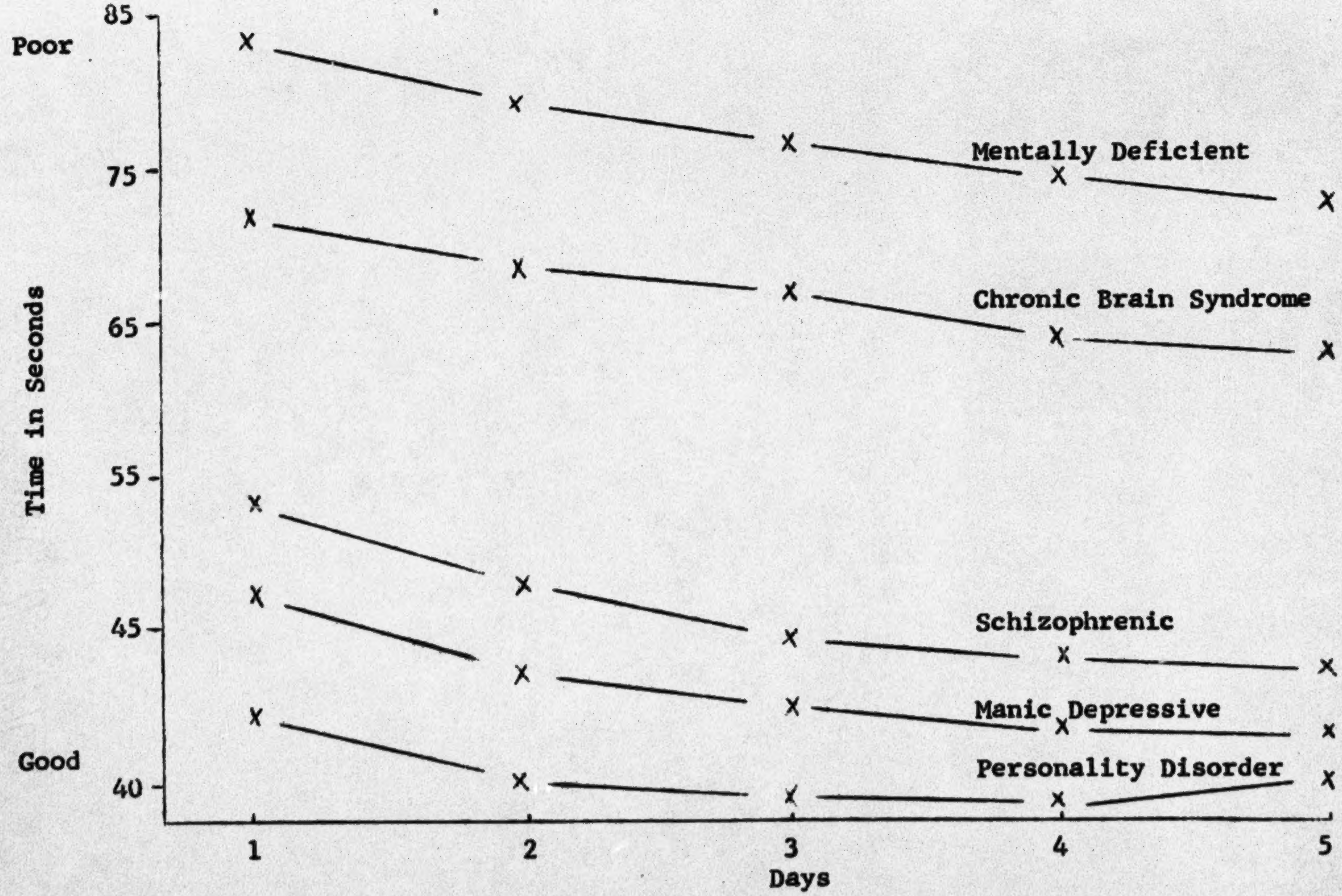


Figure A-4 The mean performance on the assembly test on each day for the five diagnostic groups.

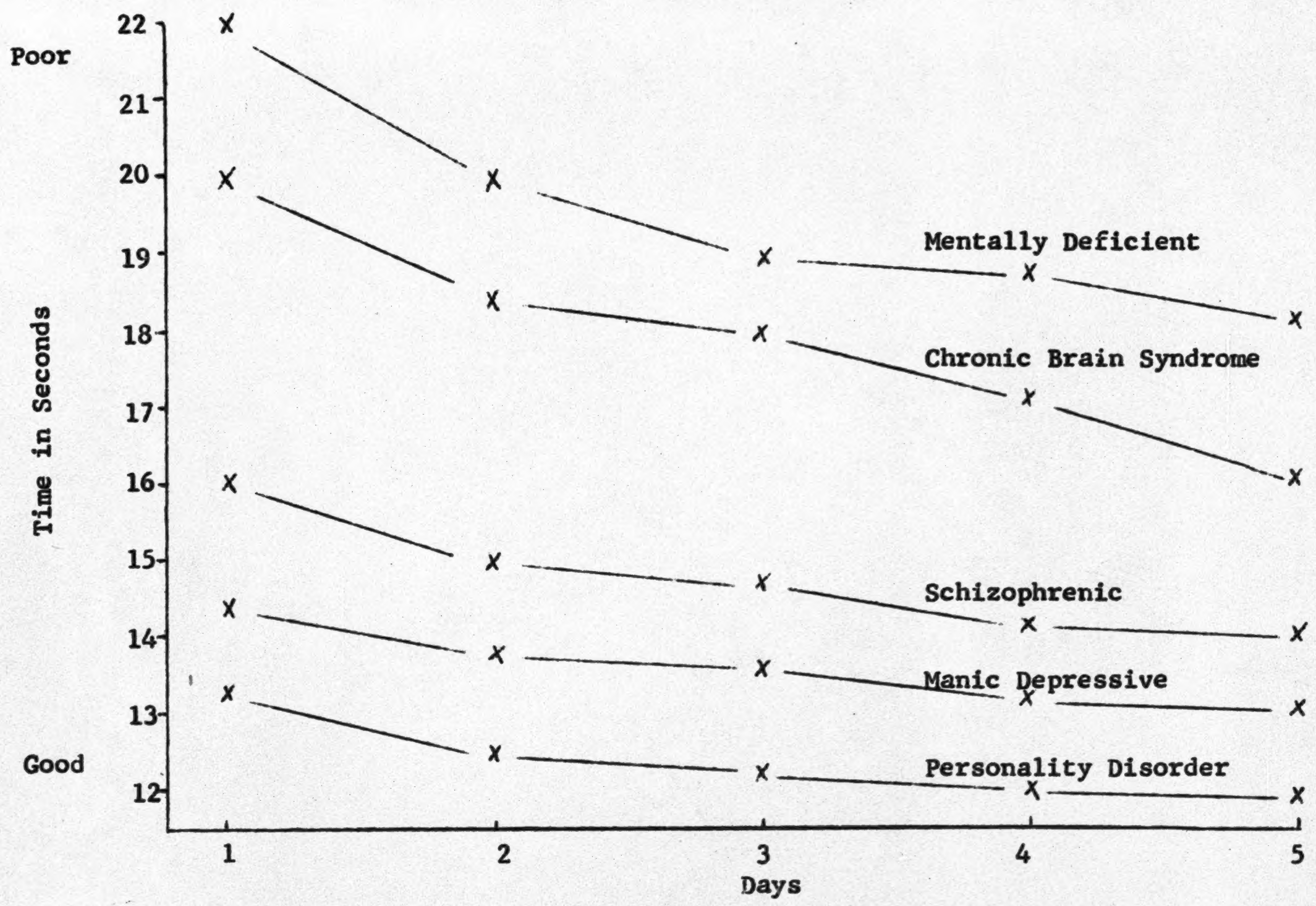


Figure A-5 The mean performance on the serial reaction test on each day for the five diagnostic groups.

A very simple and uncomplicated demonstration of the selection power of the tests was made by using the cut-off scores mentioned in Chapter 5. For each subject, the mean score on each test was compared with the cut-off score (point which cut off two-thirds of the 'out' group). Performance exceeding the cut-off was defined as 'passed', below as 'failed'. Thus each individual could be placed in one of six classes ranging from '0 passed' to '5 passed'. The results of this analysis arranged by diagnostic group and outcome are presented in Table A-19 and graphically in Figures A-6 through A-11.

Before considering these data in detail, it would be well to review certain aspects previously mentioned. The schizophrenic group was selected for analysis not only because it was the largest, but also because it had the in/out ratio at nearly 50 per cent; 43/57 to be exact. In at least two of the diagnostic groups, this ratio is badly out of balance, being 9/1 in the mentally deficient group and 8/2 in the chronic brain syndrome group. This factor will obviously place severe limitations on the selection ability of the tests. In the instances where this imbalance results in small N's, it may well be necessary to ignore the statistically unreliable behavior of these small groups and consider only the more stable larger subgroups.

The phenomena under discussion can be most readily visualized from the graphs. Figure A-6 for the schizophrenic group shows a typical relationship between the 'in' and 'out' groups when there is a positive relationship between outcome and number of tests passed. The two curves are nearly symmetrical with no reliable difference only at point 2 and 3.

Considering next Figure A-7 for the manic depressive group, the curve for the 'out' group, which is based on 70 cases, is quite similar to that for the 'out' schizophrenic group. The curve for the 'in' group, with 14 cases distributed on six intervals, is essentially random.

The same effect in reverse is seen in Figure A-8 for the chronic brain syndrome group. Here the curve for the 'in' group, based on 81 cases, is stable and in general conformity to the similar curve for the schizophrenic group.

Essentially similar to the curve for the manic depressive 'out' group is the curve for the personality disorder group in Figure A-9, although the number of cases passing all five tests is reliably greater for this group. The 'in' group is essentially random.

Possibly the best example of the effects of a small N is contained in Figure A-10 which shows the data for the mentally deficient group. With a total of eight cases in the 'out', the three which fall into the 'one passed' category boost the per cent way up to 37.5 per cent. The form of the 'in' group curve is quite usual except for the pile-up in the 'none passed' category.

Figure A-11 shows the result of an attempt to display the results of the selection technique when the imbalance previously discussed is minimized. This was accomplished by creating a composite curve from which were eliminated those small elements discussed above which tend to upset the per cent base unduly. Those elements eliminated were: manic depressive 'in', chronic brain syndrome 'out', personality disorder 'in', mentally deficient 'out'. The result is a fairly regular and symmetric curve which clearly portrays the difference in performance of the 'in' and 'out' groups.

Table A-19

Analysis of number of tests passed by diagnostic group and outcome.

			Number of Tests Passed											
			0		1		2		3		4		5	
		N	N	%	N	%	N	%	N	%	N	%	N	%
Schizophrenic	Out	363	28	.8	32	9	38	10	63	17	80	22	122	34
	In	273	101	37	49	18	38	14	32	12	24	9	29	11
Manic Depressive	Out	70	3	4	5	7	6	9	12	17	18	26	26	37
	In	14	3	21	3	21	1	7	2	14	2	14	3	21
Chronic Brain Syndrome	Out	21	4	19	3	14	3	14	3	14	6	29	2	10
	In	81	34	42	20	25	17	21	5	6	5	6	0	0
Personality Disorder	Out	67	0	0	0	0	2	3	4	6	12	22	46	69
	In	24	2	8	5	21	2	8	6	25	5	21	4	17
Mental Deficiency	Out	8	2	25	3	38	1	12	0	0	2	25	0	0
	In	75	47	63	13	17	7	9	5	7	1	1	2	3
All Groups Combined	Out	529	37	7	43	8	50	9	82	15	121	23	196	37
	In	467	187	40	90	19	65	14	50	11	37	8	38	8

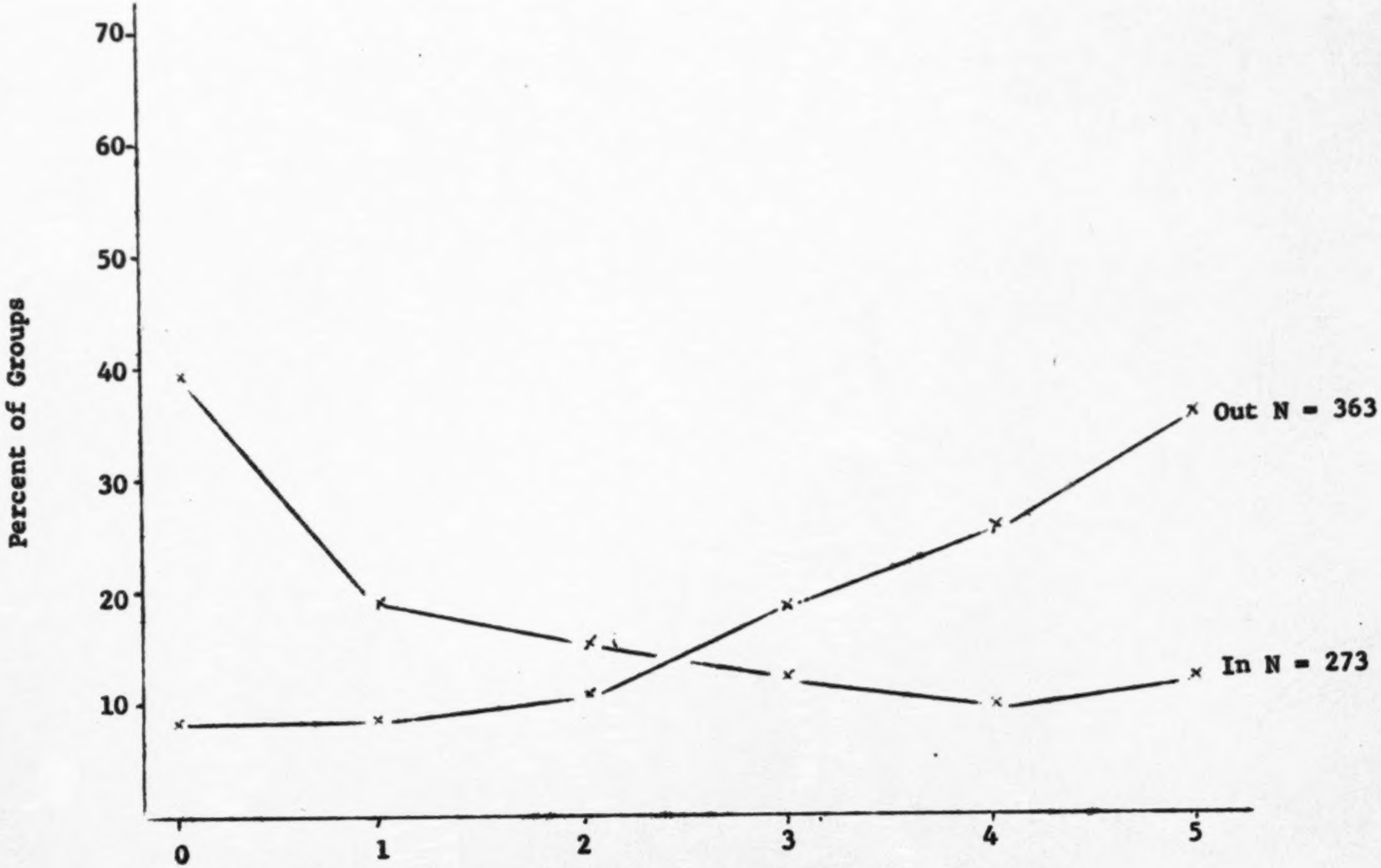


Figure A-6 The number of tests passed for the 'In' and 'Out' groups of the schizophrenic diagnostic category.

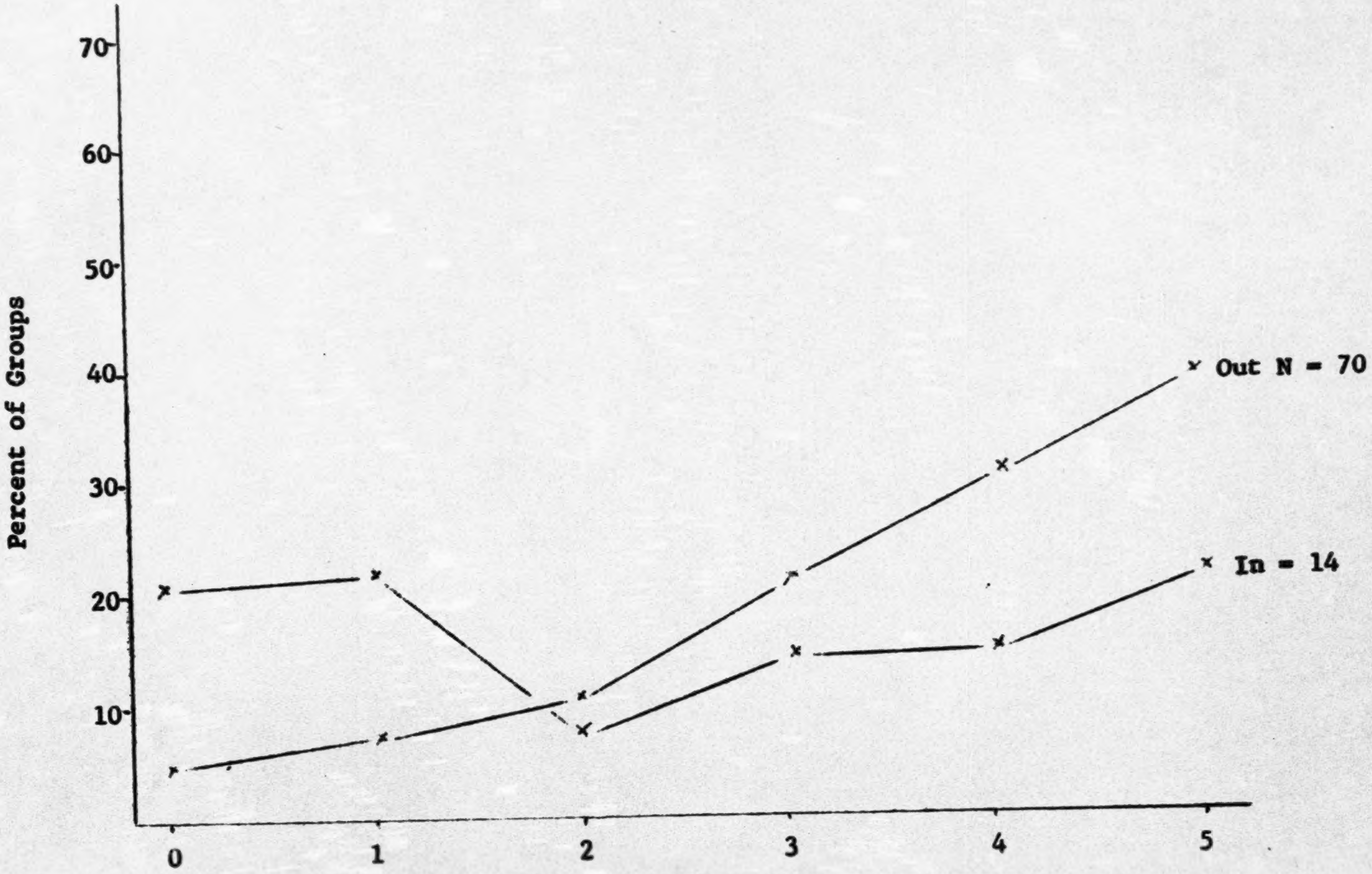


Figure A-7 The number of tests passed for the 'In' and 'Out' groups of the manic depressive diagnostic category.

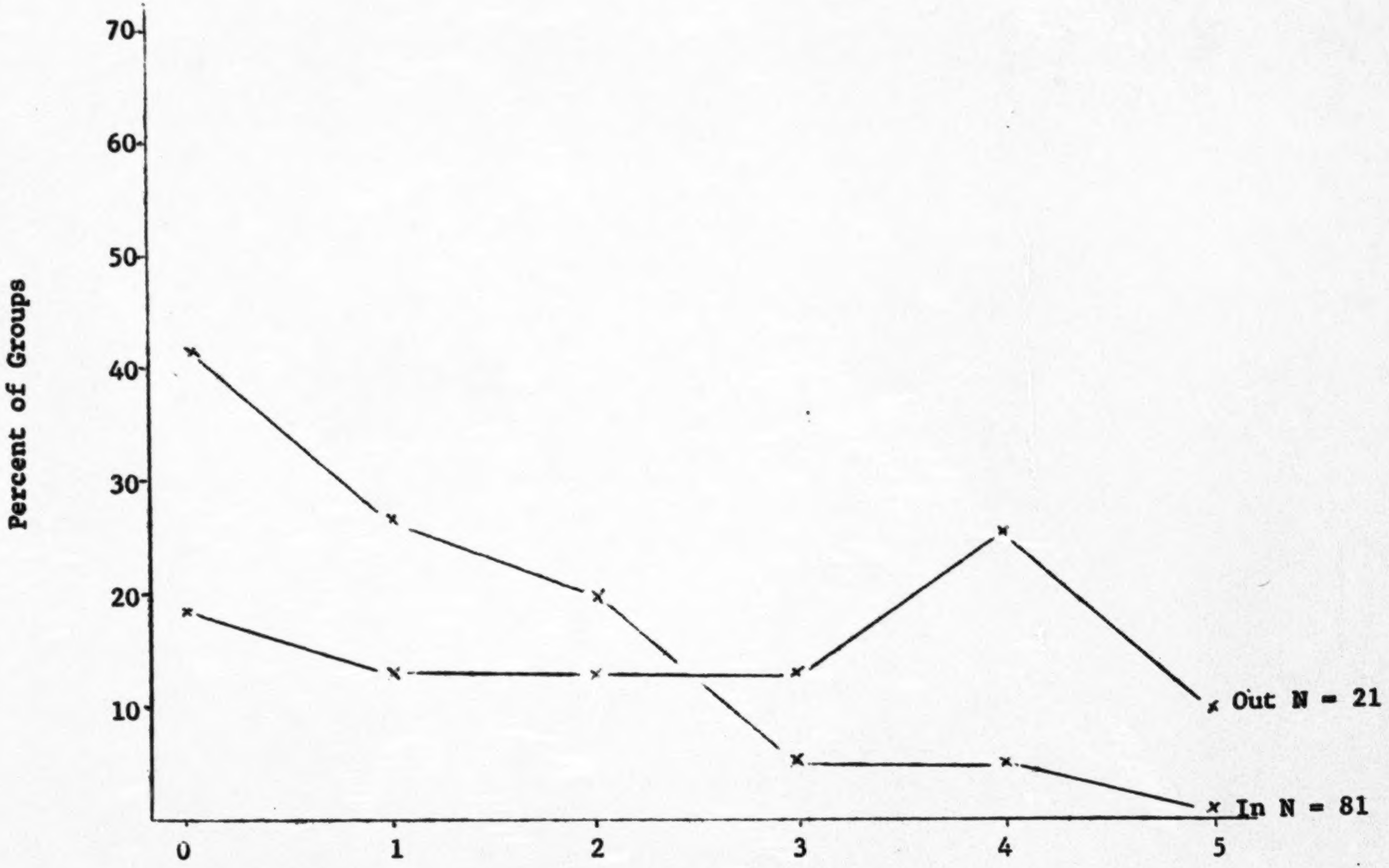


Figure A-8 The number of tests passed for the 'In' and 'Out' groups of the chronic brain syndrome diagnostic category.

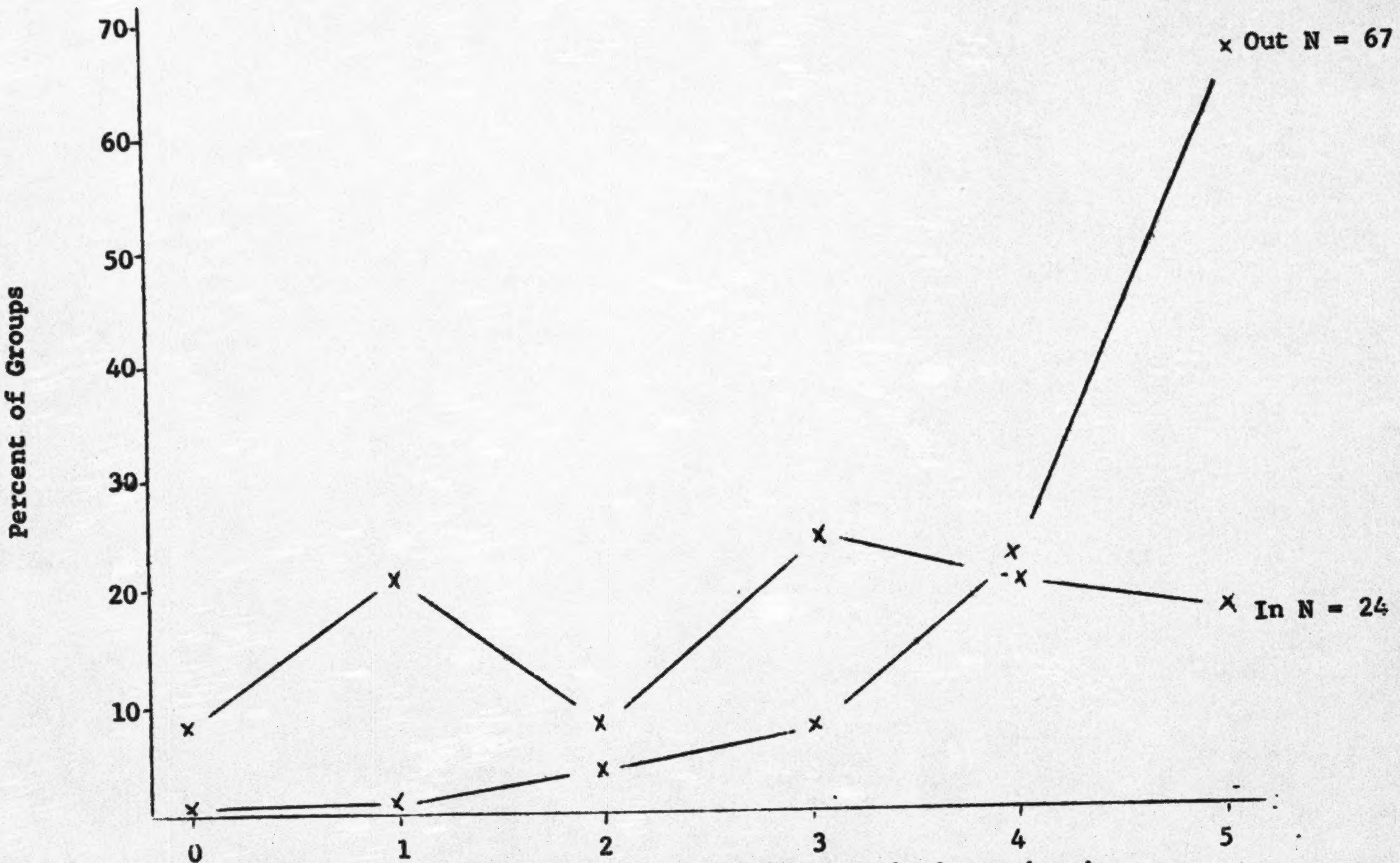


Figure A-9 The number of tests passed for the 'In' and 'Out' groups of the personality disorder diagnostic category.

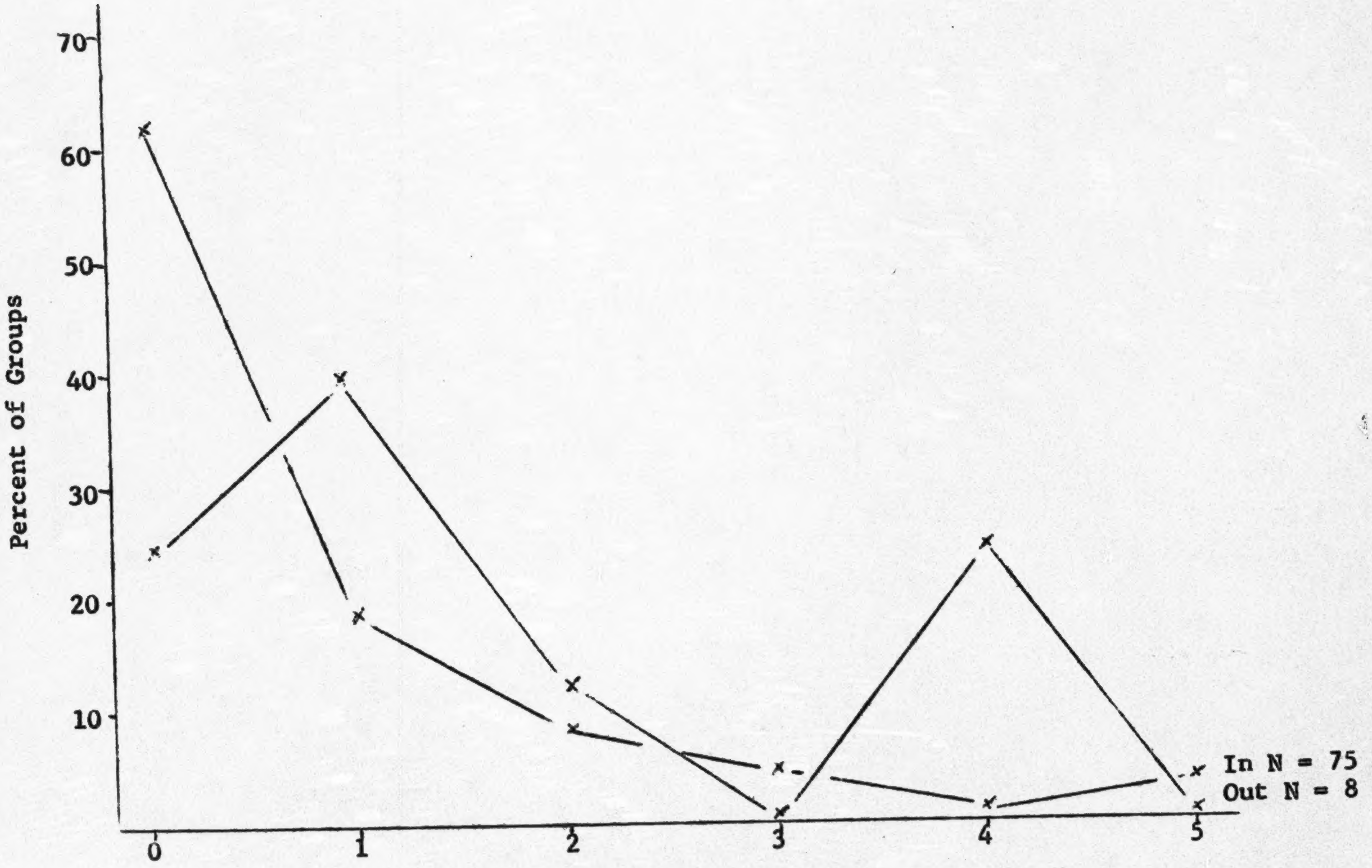


Figure A-10 The number of tests passed for the 'In' and 'Out' groups of the mentally deficient diagnostic category.

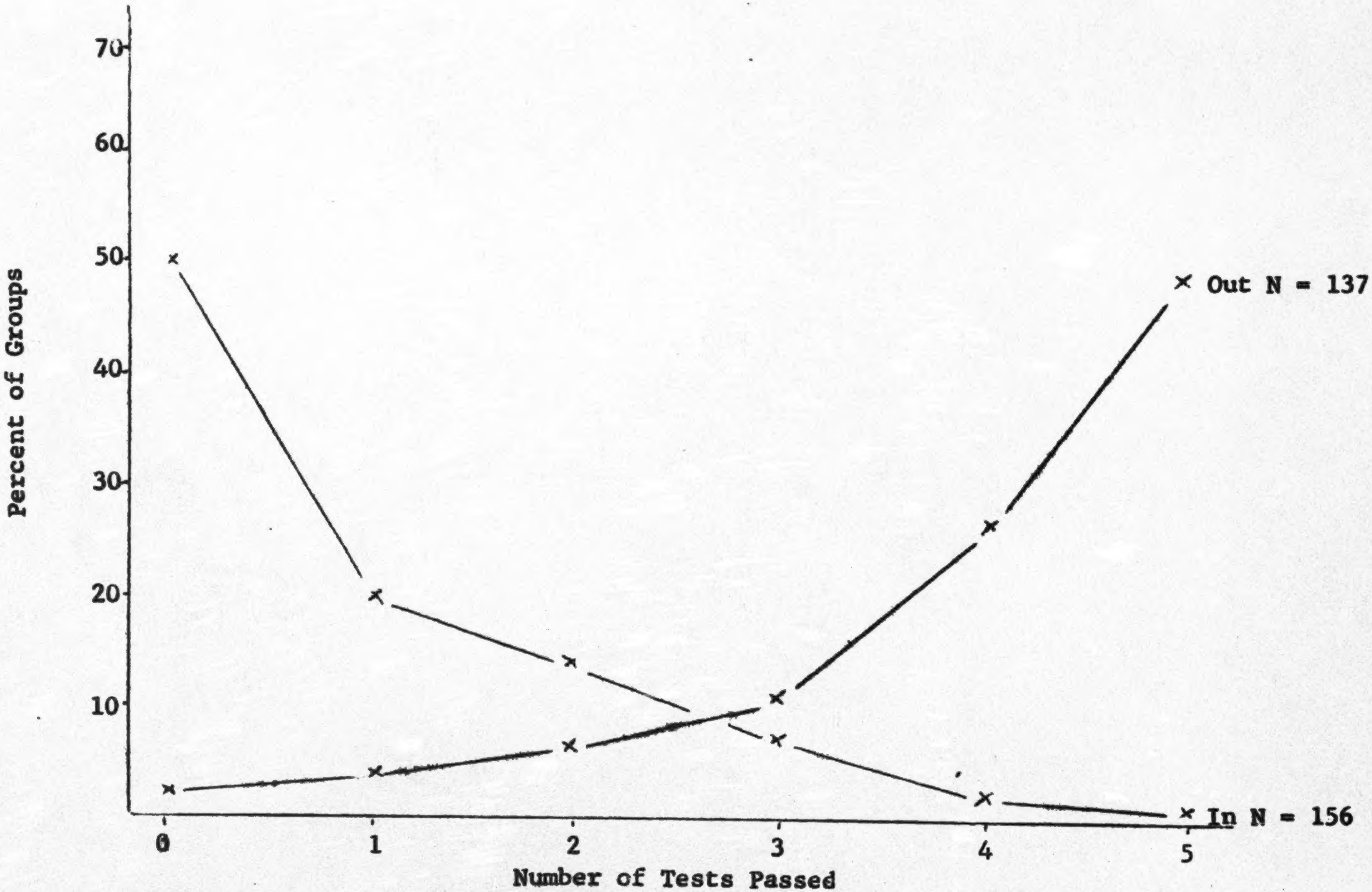


Figure A-11 Composite Curve Based on Major Groups of Diagnostic Groups 2-5.
Does not include: 2-in, 3-out, 4-in, 5-out.

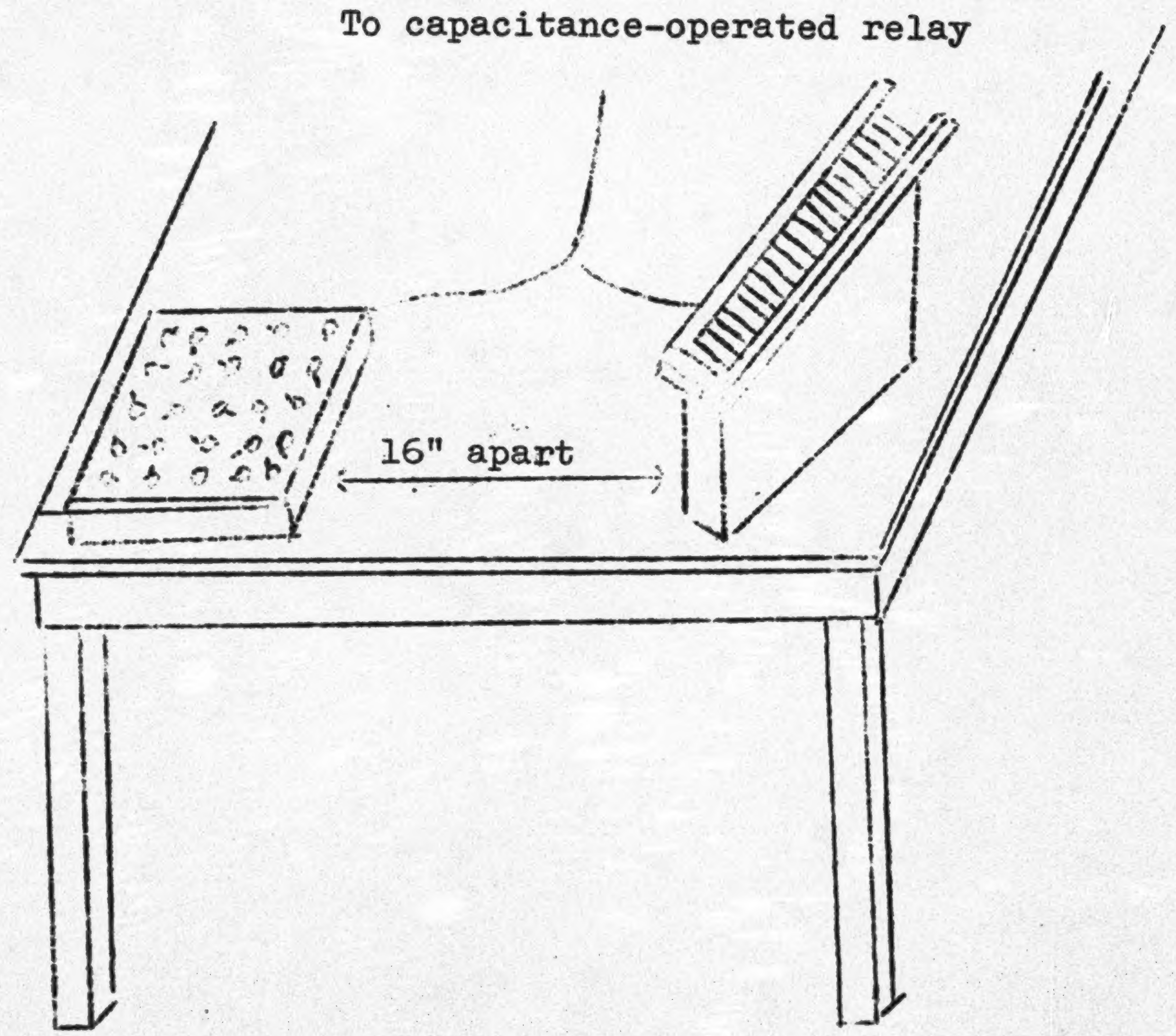

To capacitance-operated relay
16" apart

Figure A-12 Arrangement of the two major elements of transport assembly test (pegboard and peg magazine)

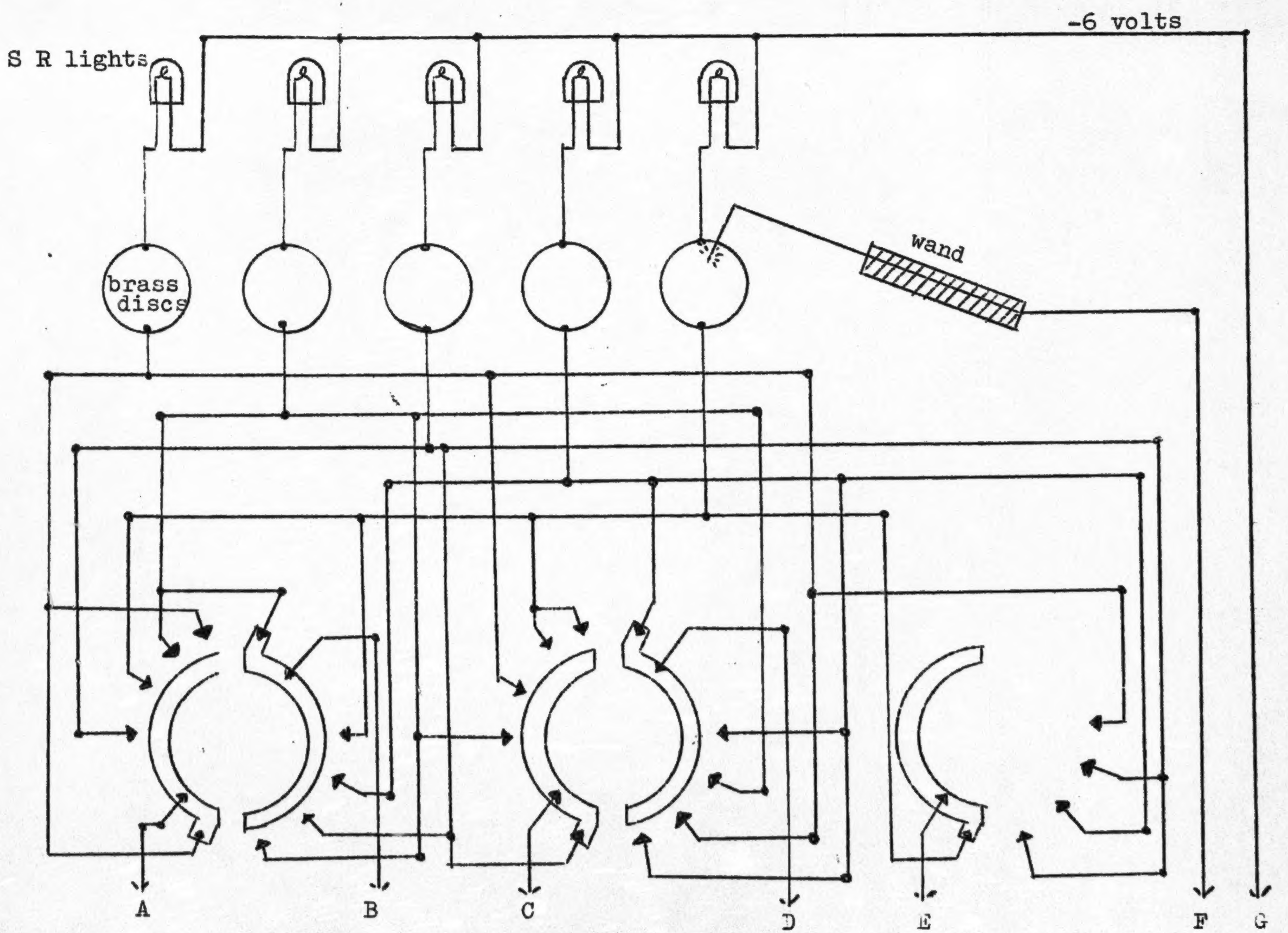

S R lights
-6 volts
brass discs
wand
A
B
C
D
E
F
G

Figure A-13 Circuitry for selector switches, discs, and light for serial reaction time test
Lettered points connect to matching letters on other diagrams

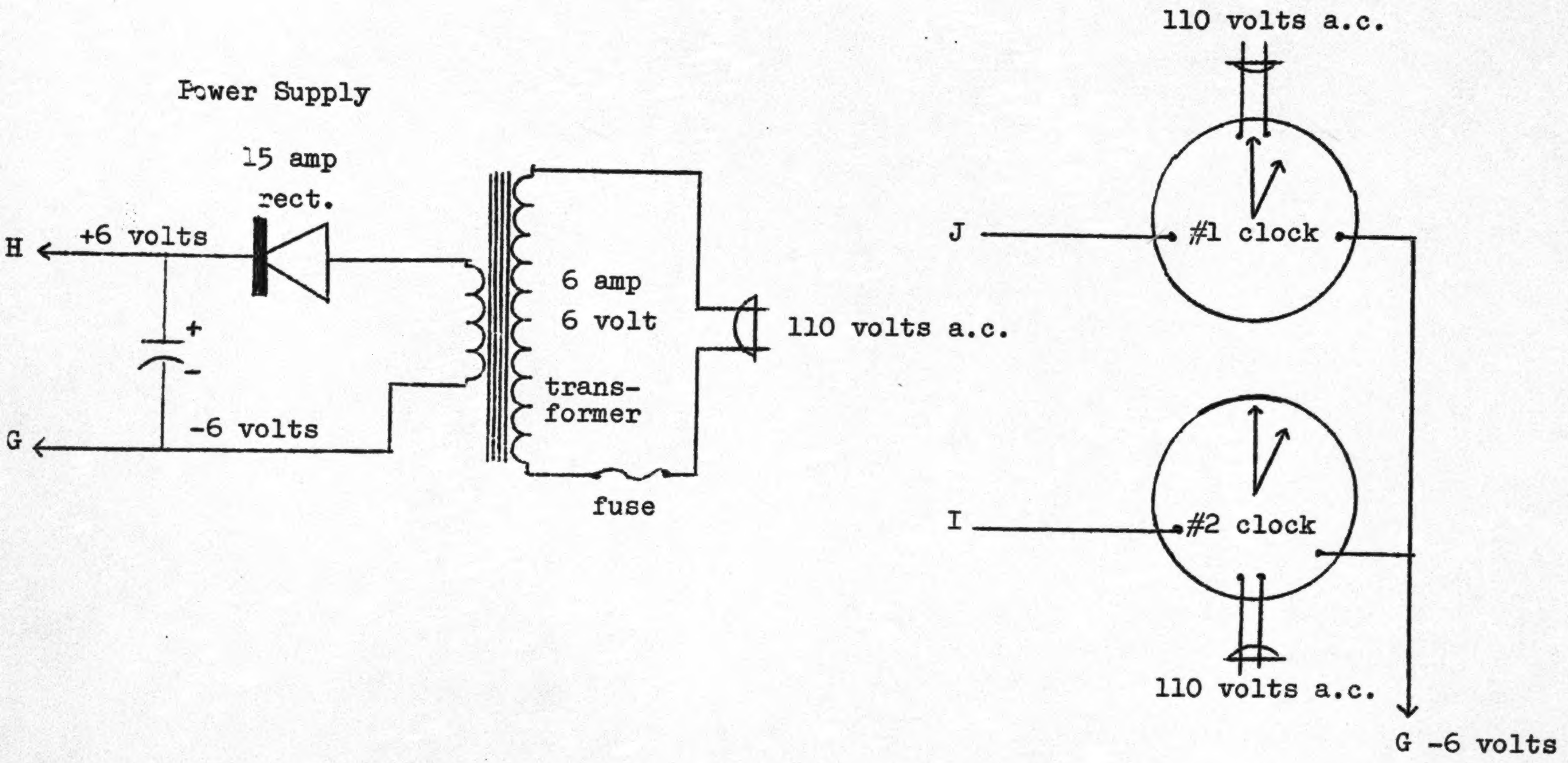
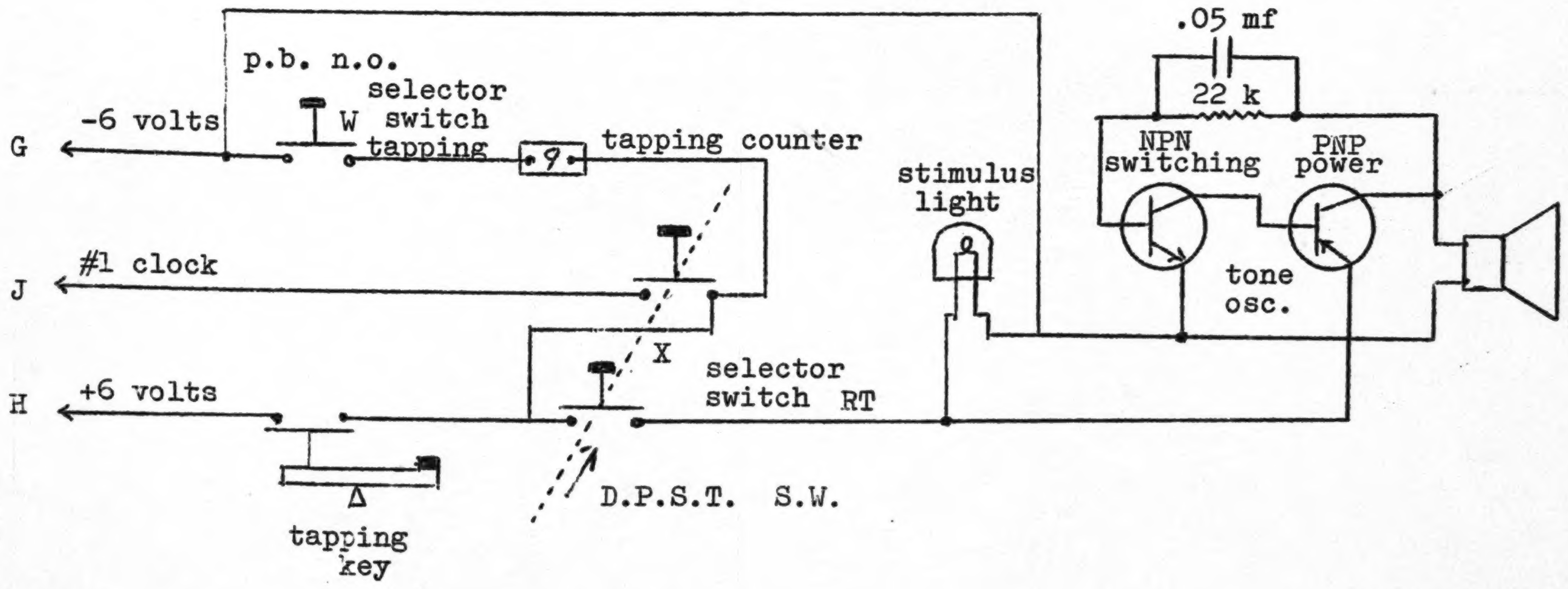

Power Supply
15 amp
rect.
H
+6 volts
+
-
G
-6 volts
6 amp
6 volt
trans-
former
fuse
110 volts a.c.
110 volts a.c.
J
#1 clock
I
#2 clock
110 volts a.c.
G -6 volts

Figure A-14 Power supply and timing clock circuitry for entire unit



p.b. n.o.
selector
W
switch
tapping
G
-6 volts
9
tapping counter
J
#1 clock
X
H
+6 volts
selector
switch RT
D.P.S.T. S.W.
tapping
key
stimulus
light
.05 mf
22 k
NPN
switching
PNP
power
tone
osc.

Figure A-15 Circuitry for tapping and reaction time test

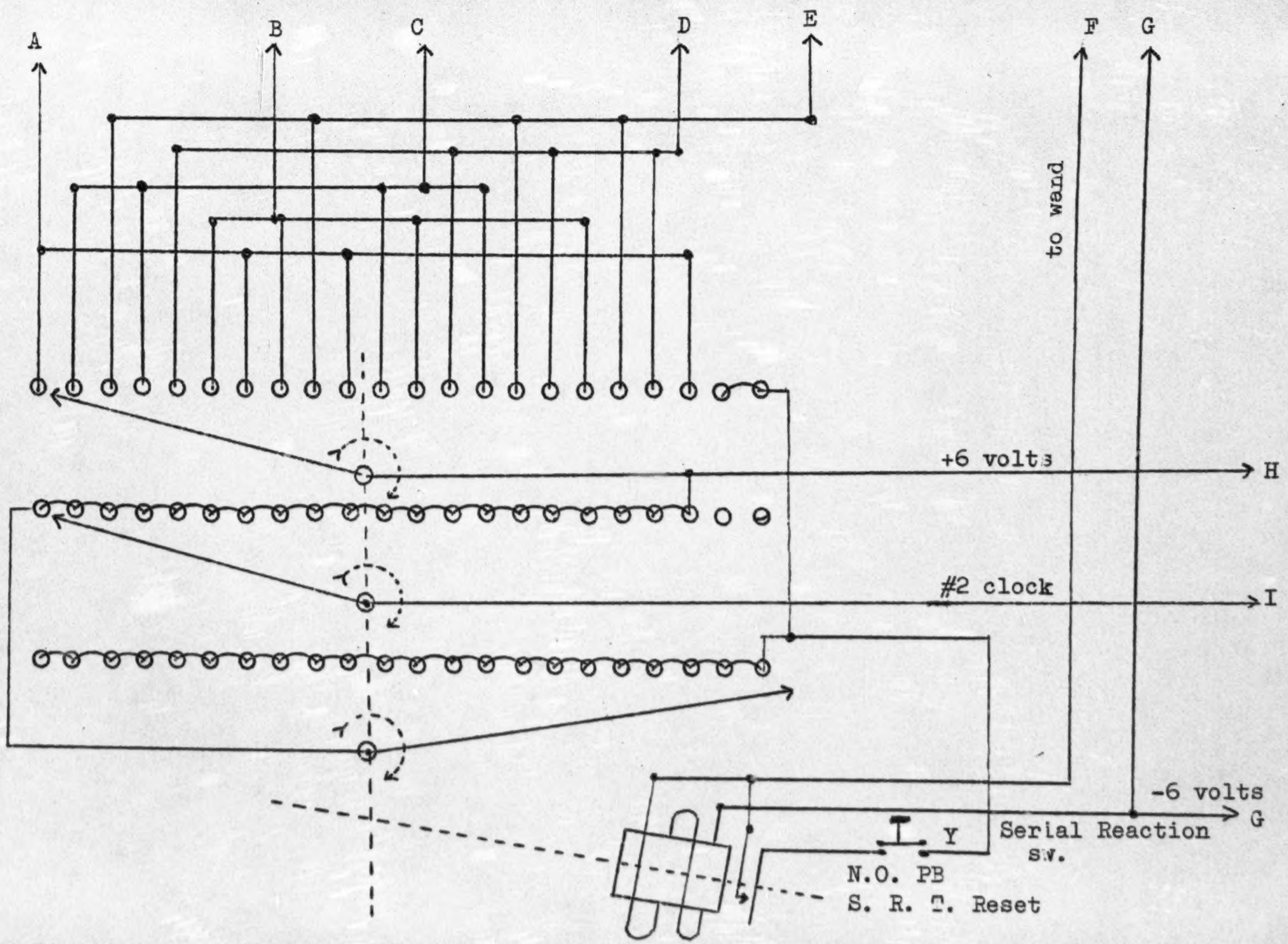

A
B
C
D
E
F
G
to wand
+6 volts
H
#2 clock
I
-6 volts
G
Serial Reaction
sw.
Y
N.O. PB
S. R. T. Reset

Figure A-16 Stepping relay circuit for serial reaction time test

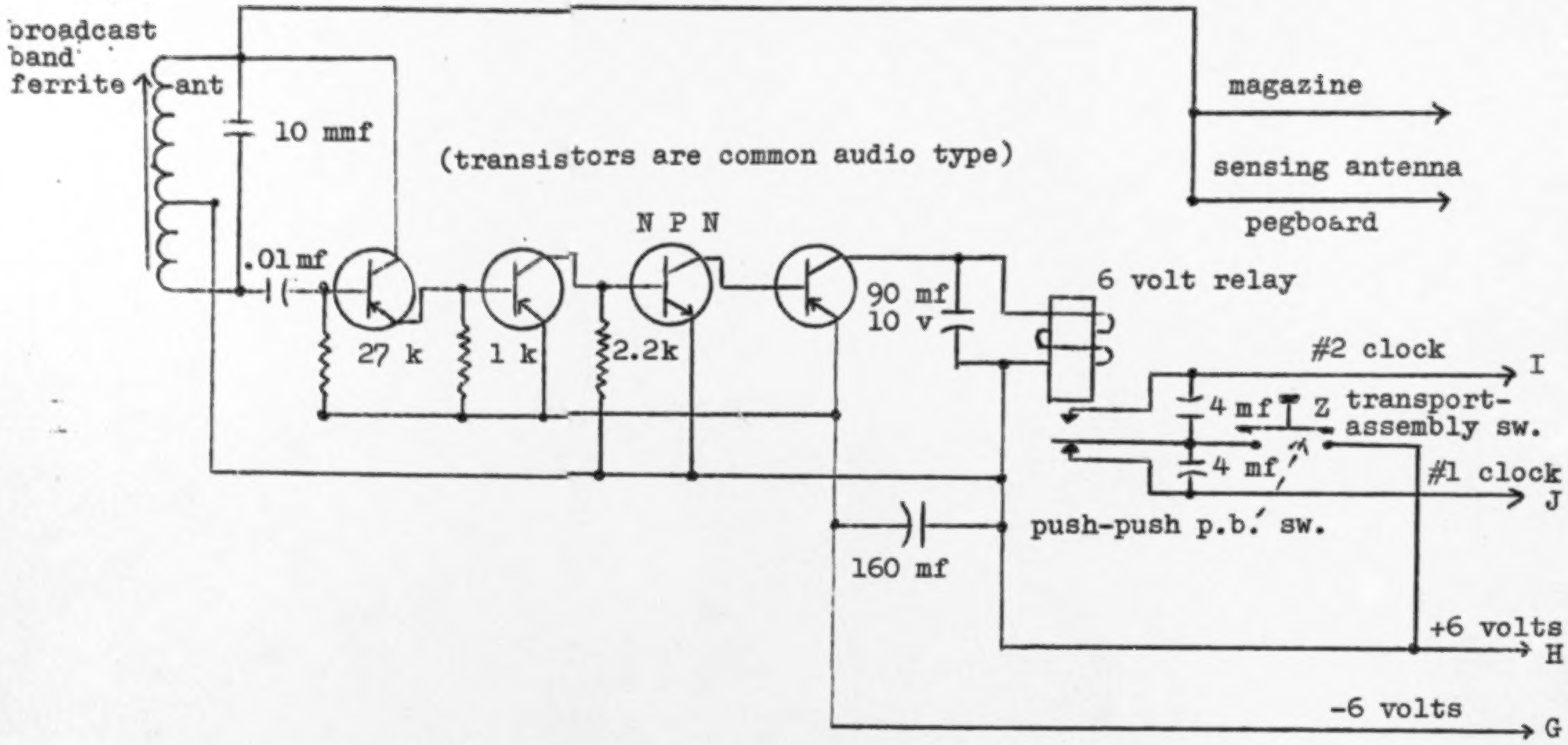

broadcast
band
ferrite
ant
10 mmf
(transistors are common audio type)
N P N
.01 mf
27 k
1 k
2.2k
90 mf
10 v
6 volt relay
magazine
sensing antenna
pegboard
#2 clock
I
4 mf
Z
transport-
assembly sw.
4 mf
#1 clock
J
push-push p.b. sw.
160 mf
+6 volts
H
-6 volts
G

Figure A-17 Capacitance operated relay for transport assembly test

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